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The Manhattan Suspension Bridge Towers.

The design and construction of the towers of the Manhattan suspension bridge across the East River between Manhattan and Brooklyn, mark a distinct era in certain parts of suspension bridge design and construction. The earlier idea of the supports of the cables of this class of structures was that of stiff and rigid towers whose tops should not sensibly yield laterally under any varying conditions of loading or season. This statement was equally true whether of the old timber towers or the later solid masonry constructions. The masonry towers of the Niagara railroad suspension bridge were removed but a comparatively few years ago and their supposed or intended solidity is still within easy recollection of most practising engineers of the present time. The massiveness and dignity of the Brooklyn Bridge towers is a daily reminder to all the inhabitants of New York of the fundamental principle of rigidity desired to be secured in suspension bridge tower construction. It was the supposition that the cable saddles upon rollers would always have sufficient mobility to allow the cables to adjust themselves freely at the tops of the towers to the changing requirements of temperature or loading. Extended experience in the maintenance and operation of this class of bridges has shown that that desired mobility is largely a matter of hypothesis. In fact, it is one of the most serious difficulties in the present problem of administering and maintaining the Brooklyn Bridge to control the traffic so as to prevent the movement of the saddles at the tops of the towers, although in this particular case the general conditions are complicated by the existence of ties running directly from the tops of the towers to various points in the stiffening trusses.

The development of the long-span suspension bridge has shown the necessity of greater freedom of movement of the tops of towers than was at first recognized. Indeed, this recognition has gone to such a length that engineers have proposed towers of single struts or columns hinged at the top and bottom, with the cables secured to the tops, thus making a rocking member of the tower. This was even proposed for the Manhattan bridge, although in the many changes of design to which that structure has been subjected, a tower fixed at the foot was finally adopted. Whether the tower is hinged at both top and bottom is, as a matter of fact, not of great moment as a structural principle, so long as it is designed to take such a horizontal motion at its top, parallel to the axis of the bridge, as may be required by the cable in consequence of the varying demands upon it. The late George S. Morison, while engaged on the North River Bridge Board, a Federal board appointed by President Cleveland, expressed the confident opinion that it was entirely consistent with good design to attach the cables to the tops of the towers and construct the latter to be subjected to such a suitable bending motion within safe limits of stress.

The Manhattan Bridge towers and their erection have been fully described in the issue of this journal of April 4, and in previous numbers, and on reference to those descriptions it will be found that these advanced views of design have been judiciously and conservatively met. At the same time these towers have been so formed as to meet the legitimate aesthetic requirements of such a great structure. Each of the towers forms simply a great steel column, 282 feet high, rigidly secured to the masonry on which it rests and supporting the cable saddle at its top. It is designed to take not only wind and vertical loads (dead and live) of the structure, but also the bending stresses produced by the unbalanced longitudinal pull of the cables induced by the various conditions of loading or temperature. As stated in the description printed last week, there may be a total range of motion of 2 ft. at the top of a tower, although it is expected that a total range of 16 in. only will be reached. The recognition of these stress conditions and the legitimate provisions for them are a marked advance in the design and construction of such great bridges. It is a rational development and makes the adaptation of the stiffened suspension bridge to great lengths of span more certain and conservative.

There is another feature of these slender steel towers which is of much practical value especially where great lengths of span are involved. The speed and economy of their construction, as has been evidenced during the past few months by the rapid putting in place of the Manhattan towers, are markedly evident. Anyone who remembers the slow and costly construction of the Brooklyn Bridge massive masonry towers can make a most interesting and important contrast with the simplicity and speed of erection of the four towers but little farther up the East River for a far heavier structure and with practically the same length of span.

State Supervision of Sewage and Water Purification.

The supervision of sewage and water purification works by the State in which they are located, together with the amount of authority which should be delegated to a state commission to compel the construction of works for purifying sewage and water, is a subject fast coming into prominence in some parts of the country. There is a general recognition of the fact that it is necessary to purify sewage before discharging it into some bodies of water and there is an equal recognition of the necessity of purifying water supplies obtained from sources likely to be contaminated. These things are thoroughly well established and are recognized by the intelligent people in every community. There is a great diversity of opinion, however, regarding the amount of authority that should be given to State officials to compel local communities to carry out such works and to operate them in an efficient manner. A good many people hold that such works are purely local matters and if the communities interested in them choose to neglect them, that is something in which the State is not concerned. As a matter of fact, this view is entirely wrong. In these days of manifold means of communication between different communities, it is firmly established that disease is carried from one community to another by people in their travels. Some time ago a favorite vessel for summer travelers on the Great Lakes had its water tanks filled with polluted water. As a result of this, a considerable number of its passengers were stricken with typhoid fever, and this disease was introduced in consequence into many cities. This is an extreme case, of course, but it shows that the health conditions in a community are of more than local importance. In the same way, a city which discharges its sewage without any purification into a stream that, lower down, furnishes water for the domestic uses of another community, is unquestionably acting in a manner prejudicial to the health of the latter, and the State is warranted in interfering to prevent a continuance of this dangerous condition. While the works are local, the conditions they are intended to remedy are widespread and State supervision is therefore warranted.

While a good many attempts have been made to pass laws which will result in a satisfactory degree of supervision over such sanitary works, they have not, except in a comparatively few cases, proved entirely successful. The reason for this is that they have generally been either so drastic as to be impracticable of application or so general in their nature as to have no particular force. Occasionally the execution of some pretty fair laws has been entrusted to state officials who have been altogether too severe in their requirements, and as a result have caused State supervision to be distrusted. Three things must always be considered in drafting laws of this nature. The first of these is that the methods of purifying sewage or water that are satisfactory for one place may not be at all appropriate for another, and consequently every community presents a special problem which must be studied in the light of the local conditions solely. The second thing that must be considered is that what the State desires is security for its citizens, and not the universal adoption of some particular method of sewage disposal or water purification. Some silly laws have been passed on account of a failure to appreciate that results and not methods are what the State must call for. There may be several different ways of disposing of sewage satisfactorily in a given community and the State has no ground for interfering in the selection by the community of any one of these methods; its province lies in compelling the community to adopt a method which will yield the desired results and in seeing that this method is so practised that the results are obtained continuously. In the third place it is necessary for the State to recognize that many communities are badly situated financially, their limit of indebtedness being already reached. In such cases it is, of course, necessary to extend the debt limit in some way, and inasmuch as methods of preventing the pollution of streams and of purifying water are essentially water-works propositions, which are not generally considered in connection with questions of debt limits, the State can assist the cities and towns in such work by permitting them to issue bonds, in excess of their regular debt limit, for such purposes.

Late last month the Ohio legislature passed a bill turning the control of stream pollution, sewage purification and water purification over to the State Board of Health. This bill, which is printed in full elsewhere in this issue, is not based on theory, but on some fifteen years of practical experience on the part of the State Board of Health in endeavoring to secure safe water supplies and proper sewerage for Ohio municipalities. The work of the Board during the last two years especially has shown the need of a control of the installation as well as the operation of water and sewage purification plants. This central control is necessary in order that the matters relating to works of this nature may be adjusted with due regard to the respective rights of different cities, some of which discharge sewage into the water supplies of others, and without imposing unreasonable expense on any one city. The bill requires the State Board of Health to investigate the pollution of a stream at the request of local officials, or it may make such an investigation at its own initiative. If it finds that sewage purification works are necessary or that the existing works must be changed, it can order such work to be carried out within a definite time, provided there is a public hearing on the subject and the orders of the Board have been approved by the governor and attorney general. This last provision, it will be seen, insures that the results of the sanitary engineering work of the State Board of Health shall be passed upon by the governor, who may be expected to decide matters of public policy, and by the attorney general, who will consider the legal aspects, before the order is finally issued. Such a procedure will rob the orders of any of those features of harshness and tactlessness that have been manifested in orders issued by health officers in some States in past years. The same procedure exists under the new bill with respect to water purification works. Means are provided for forcing local officials not only to build but also to operate works properly. The orders are not absolute, for an appeal from them can be made to an arbitration commission of experienced sanitary engineers. This is probably the first time that a bill specifically provided that an engineering subject should be arbitrated by engineers exclusively. There has been no bill introduced in any other State during the present season which bears the earmarks of more careful study. While some of these provisions may need modification, The Engineering Record is inclined to regard it as the most satisfactory law yet suggested, and it hopes that in its enforcement great tact will be shown at first, so that the merits of the law may become fully demonstrated by experience before attacks are made on it, as they are bound to be made on it, when vigorous action is taken against some communities which refuse to safeguard the health of their citizens.

An Unusual Turbine Plant.

The addition to the Centerville plant of the California Gas & Electric Corporation, which was described in this journal on March 21, deserves more than casual notice from the engineer. It is typical of modern ideas in hydroelectric design in more than one respect. This Centerville plant is near the northern extremity of the great network that supplies power to a large part of the State of California and a transmission from it to San Francisco or to Sausalito would span more than two hunderd miles. It is one of about a dozen plants which supply power to the system, and hence it cannot be laid out along the lines which would be canonical for a single station. The whole plant is but a unit of the generating system and its whole power could be concentrated in a single generator without violating any rule of sound practice. This is pretty nearly what was actually done. The plant contains but two units and one of these, the new one, is a 5500-kw. generator coupled to a 9700-h.-p. turbine. The older unit adds but 1500 kw. to the total. The result is an extremely simple and compact station delivering 7000 kw. to the system. Including the transformer room and the whole wheel and generator equipment, this station delivers more than 2 kw. per square foot of floor space, at a pinch nearly 2.5 kw. As a study in economy this is respectfully put up to Eastern engineers, who are somewhat prone to stations of magnificent distances in which even the switchboard and bus-bar compartments belong to the class of spacious cloisters.

From the hydraulic standpoint the striking feature of the Centerville plant is the use of a regular reaction type of turbine for the 5500-kw. unit at an effective head as great as 550 ft. The ordinary practice under such conditions has been to use impulse wheels of one form or another on account partly of the speed conditions and partly of the difficulty of getting a turbine to stand up under the high velocity of the water, often carrying some sand in suspension. For the development of moderate power at any convenient speed the impulse wheel is extremely well suited but as the output rises there comes a necessity for more and bigger nozzles, met commonly by the use of double or triple nozzles and often by the addition of another wheel on the same shaft. By the time this is done it is fairly evident that further increase could well be made by making the entire periphery of the wheel active and this leads naturally to regular turbine construction as it has in this case. Given the requirement of large output and the turbine meets the needs of the case admirably. The next question is the endurance of the turbine at such heads. The older turbines of cast iron proved generally inadequate. The Centerville turbine is in all essential parts of steel, the runner being a solid steel casting on a forged steel shaft. Governing is accomplished by shifting the guide blades which are forged solid with their pivots and held between steel rings. Especial care has been taken in the hydraulic works to free the water from grit and there seems to be no reason why the wheel should not stand up in service quite as well as an ordinary impulse wheel.

The wheel is designed to have its maximum efficiency at the normal load of the generator since the station is intended to run at normal load, the regulation of the system being attended to elsewhere. This is one of the important things which can be accomplished on a big electric net work. In an ordinary station, regulation is a constant source of worry and has to be provided for at every point to meet the requirements of varying conditions. With a net work into which a number of stations feed, the work of regulation can be in a measure specialized, so that most of the plants can be run at nearly constant load, the variations being taken up by the plants best fitted to do it economically. In addition the bigger the system the steadier the load, as a rule, so that there is gain at all points, and especially in economy of water. In the older impulse-wheel plants, the governing was accomplished by deflecting nozzles which caused a lamentable waste of water. In some later plants an improvement has been made by the use of the needle valve, but after all the gate valve of the turbine is the most satisfactory method of economical governing, which is another gain from using the turbine in this case. Incidentally one may mention the fact that on a network like the one involved in this case, there is a distinct saving of water to be made by proper choice of the governing stations, the burden being best thrown on those which have liberal storage. The economic gain from uniting many plants in a system like this is even now but half understood. It is the largest feature in its possibilities to be found in modern power development, involving as it does not only the advantageous union of plants but of separate water sheds with different and mutually helpful characteristics of flow. With such a union of resources and a suitably interlinked distributing network the service is more economical and reliable than can be otherwise attained, in spite of the long transmissions.

Limitations of Running Repairs in Equipment Maintenance.

The maintenance of engineering equipment in service broadly includes inspection, adjustments, light repairs and general overhauling. In the operation of many systems the first three of these four branches of maintenance are grouped together under the head of running repairs. Neglect of these leads to service irregularities and interruptions, but the failure to look after general overhauling at the proper times inevitably results in the excessive depreciation of the machinery involved and too high a maintenance cost for apparatus of a given capacity. In some lines of work, as in the maintenance of electric cars on a large scale, it is necessary to sharply separate running repairs from general overhauling. The car-house force on a highly organized system handles many minor repairs and adjustments that on a small road would be looked after in the shops. If the shops of a very large system operating a thousand cars or more were to make all of the running repairs that can just as well be carried on inside the car storage houses, the former would soon be swamped with work and the remedying of the more serious troubles would be greatly delayed. In like manner, if a large manufacturing plant attempts to handle its repairs of an extensive nature by part of the regular operating force instead of its construction department, the best results are not secured.

In the zeal for low operating expenses that some boards of directors display, the property tends to deteriorate much faster than would be the case if the general overhauling were not neglected in favor of carrying simply the minimum amount of running repairs that will keep the apparatus in service. It is a short-sighted policy to operate a patchwork system year after year in the penurious belief that a general overhauling will cost too much in lost time from service and in repair expenses to pay the company to make the effort. It is inevitably a drawback to have to withdraw a machine from service for perhaps several weeks at a time once in every few years in some industries, and perhaps every few months in others, but such times supply just the opportunity for the company to seize for introducing new equipment to meet the expansion of its business.

An instance of the effect of neglecting a general overhauling of a power plant may be cited in the case of a street railway company in the East, which has for some years been attempting to get along with an old steam-engine station which is in sore need of being modernized, if not rebuilt on a location nearer the center of gravity of the company's load. The equipment of this plant is so heavily taxed that the president of the company not long ago remarked that it was impossible to run another car on the system, so short are the different lines for power. In a general way the plant has grown in capacity from year to year along the lines of original design of twenty years ago, except that the belted units first installed have been at last disposed of. The station has not been kept up well, and although vertical engines of 2,000-kw. capacity or thereabouts have been installed at certainly two periods, the machinery has not been thoroughly maintained to the extent of anything like regular overhauling, and the plant is characterized by bad leaks in the water piping, an indifferent steam piping service, and a general condition of neglect. The power cost to the company in the last three years has increased about 40 per cent, while the car mileage run has increased but 18 per cent. There is every evidence that the engineers in charge of the plant's operation during the last few years have been greatly handicapped by the company's close financial policy, although there is no doubt that if the running repairs had been better kept up, the efficiency of the station would have made a better record. The style of car used has not been materially altered as far as the bulk of the rolling stock is concerned. It is not long since that this particular organization was paying its electrical engineer, a man of several years' experience, less salary than the average motorman on the streets received. It is not to be wondered that the cost of power per car mile rose from 3.7 cents in 1905 to 4.22 cents in 1906 and then to 4.35 cents in 1907. Nothing is clearer than the need on this road of a thorough general overhauling of the power situation, and until this can be done, in addition to the work of keeping the plant just able to carry the peak loads of morning and afternoon, the profits of the service are sure to be less and the reliability of the car movements at the mercy of inadequate capacity and inefficient station production.

Notes and Comments.

THE RESTRICTED WATERWAYS at bridges are occasionally the cause of considerable anxiety on the part of railway engineers. It will be recalled that the Board of Engineers of the U. S. Army which reported on the disastrous floods at Kansas City a few years ago, stated that those floods were made far more damaging by the presence of embankment approaches and piers in the river than by any other cause. It is accordingly interesting to observe in two papers read before the Institution of Civil Engineers last month that Indian engineers are intentionally restricting the waterways at river crossings for the purpose of saving expense. The Curzon Bridge at Allahabad, which crosses the Ganges, is a recent example. At the site of this structure the banks of the river are 6350 ft. apart. This width, which is the narrowest on that part of the river, has been further restricted by building solid embankments, practically reservoir dams, which force the river into a channel 3165 ft. wide, across which the bridge has been built. By substituting this embankment for trestle approaches, a saving of about $500,000 has been effected. This restriction of the waterway must, of course, result in a scouring of the channel over a considerable portion of the 3165-ft. waterway. The piers have been carried down by means of well foundations to an average depth of 100 ft. below the low-water level, where they have been founded in a clay bed. Another recently constructed bridge carries the Madras Railway across the Netravati River, where its width is about 6200 ft. In this case approach embankments 700 and 2940 ft. long have been built, and the piers have been designed with a view to the scouring of the river bed as a result of the intrusion of these embankments upon the natural waterway.

THE BROOKLYN BRIDGE was given a clean bill of health this week in a report forwarded to the Public Service Commission by the Bridge Department of New York City. It was accompanied by reports from Mr. C. M. Ingersoll, chief engineer of the Department of Bridges, Prof. Wm. H. Burr, consulting engineer, and Mr. Leon S. Moisseiff, of the engineering staff of the Department of Bridges. This is by no means the first time that the ability of the structure to carry heavy loads has been investigated. It is unnecessary to review here the many reports on the subject that have been made, but it may properly be pointed out that on Dec. 31, 1906, a commission reported that the structure was able to carry heavier loads than were then imposed upon it. In April of last year, Professor Burr went over the matter again and reported that the bridge was able to carry trains made up of six motor cars instead of four motor cars and two trailers. In the recent report he confirms this statement in detail, as does Mr. Moisseiff. It is stated that trains of six motor cars running at a maximum speed of 15 miles per hour, with a headway of 45 seconds and spaced not closer than 700 ft., will increase the stresses in the cables about 2½ per cent. and the stresses in other members somewhat more, but in no case will these stresses exceed safe limits. The engineers report that when the signal system is completed which is now under contract, the operation of such heavy trains on this schedule is entirely feasible and should cause no apprehension whatever. They further report that under the present efficient system of inspection and maintenance, which includes the correction of misfitting members originally placed in the stiffening trusses and the improvement of many details, the bridge is now in as satisfactory a condition as ever, and Professor Burr is of the opinion that the structure is even better than ever before.

OYSTERS FROM SEWAGE CONTAMINATED BEDS are to be kept out of the New York market under a regulation of the Municipal Health Department adopted this week, which reads as follows: "No oysters shall be held, kept or offered for sale anywhere in the City of New York without a permit in writing from the Board of Health, and subject to the rules and regulations of said board." While this regulation does not seem at all severe on its face, it is acknowledged that the Health Department proposes to keep out of the city all shellfish that come from beds exposed to sewage contamination. The Department has made an examination of all the sources from which oysters are obtained and it believes that by a strict enforcement of the new regulation it will prevent the spread of typhoid and other diseases by shellfish hereafter. An association of the oystermen has been formed to protect the interests of the industry, and it seems likely that a very pretty battle will be fought out soon. It is not surprising that the Health Department has determined to keep contaminated shellfish out of the market, for this action has been urged for a number of years. Those who desire to look into the matter will find an important paper on the subject by Mr. Geo. W. Fuller in The Engineering Record of Aug. 12, 1905. Investigations conducted by various parties in New York Bay show that shellfish taken from waters polluted by sewage are themselves contaminated, while shellfish that have been grown in pure waters are uncontaminated. One great source of contamination lies in the fact that oysters are prepared for the market by being "drunk" or "fattened" in fresh water creeks, and all of the creeks about New York where this process of fattening is carried on are contaminated by sewage. According to a paper read before the Boston Society of Civil Engineers some time ago by Dr. Geo. A. Soper, there are still some places in New York Bay where oysters are grown without any serious danger of contamination at present, but if more sewage is discharged into the bay by the proposed Passaic Valley trunk sewer, fear is expressed in some quarters that even these grounds will have to be abandoned under the new ruling of the Health Department. Accordingly it is not at all surprising to learn that the oystermen are joining with other interests in an attempt to prevent the discharge of the Passaic Valley sewage into New York Bay unless it has been first purified.

AN INTERSTATE WATER RIGHTS CASE of great importance has just been settled by the Supreme Court of the United States. Some time ago the courts of New Jersey decided that the Hudson County Water Co. had no right to sell water gathered from the Passaic River in that State to the Borough of Richmond, in the State of New York. The company appealed from this decision to the federal court on the ground that the ruling was unconstitutional because it interfered with interstate commerce and with property rights. The United States Supreme Court has just decided that the State has a perfect right to prohibit the sale of waters gatherel within its boundary to parties outside the State limits. The decision reads: "The private right to appropriate is subject not only to the right of lower owners but to the initial limitation that it may not substantially diminish one of the great foundations of public welfare and health. We are of the opinion, further, that the constitutional powers of a State to insist that its natural advantages shall remain unimpaired by its citizens are not dependent upon any nice estimate of the extent of present use or speculation as to future need." The decision is particularly important because it will greatly help the work of the New Jersey State Water Supply Commission, which has been entrusted with the task of preparing plans for conserving the water resources of the State. This commission has reached the conclusion that the conservation of water and the prevention of floods in the Passaic Valley will both be best served by constructing a reservoir at Mountain View at an estimated cost of about $7,500,000. Repeated investigations have shown that the rapidly increasing population in the district lying about Newark will shortly demand far more water than the present works can supply, and a number of investigations have indicated that the cheapest method of furnishing this additional water is the construction of a great reservoir at the site suggested. This basin will hold back the waters which periodically cause disastrous floods in the cities of Paterson and Passaic and will furnish an additional supply at a cost per million gallons which is probably lower than that paid by the communities for their present supplies. The projected work is one of the most useful which has been contemplated by any State for some time.

THE CHANNEL SPANS OF THE BLACKWELL'S ISLAND BRIDGE.

The recent connections of the center panels of the channel spans of the Blackwell's Island Bridge across the East River, New York, complete the principal operations in the construction of the main superstructure of the five continuous spans having an aggregate length of 3,724 ft. between anchorages and a total weight of about 53,000 tons, of which 51,000 tons is now assembled in position.

The spans of 1,182 ft. and 984 ft. over the west and east channels of the river respectively, are each composed of two equal cantilever arms directly connected together without the usual suspended span and have a far greater capacity and more massive members than any other bridge. The longest span is longer than any other truss span on this continent and longer than any in the world excepting the Forth Bridge. Both spans, together with the 630-ft. connecting span across Blackwell's Island and the anchor arm spans on shore, have pin-connected trusses in vertical planes, 60 ft. apart, carrying at lower chord level, a deck with a 53-ft. carriageway, including two railroad tracks between the trusses and two tracks on cantilevers outside the trusses and an upper deck with a capacity of four railroad tracks between the trusses and two promenades outside the trusses. The depths of the channel span trusses are 185 ft. over the main piers and a minimum depth of 45 ft. at the center. Each anchor span is approached by a long and high steel viaduct which together extend the total length of the bridge to 7,424 ft. between terminals. The bridge has an estimated capacity of 150,000,000 car passengers yearly and the original estimate of $12,500,000 total cost will probably be considerably exceeded before its completion which it is now hoped may be accomplished this year. Work on the sub-structure was commenced in July, 1901, the first contract for the superstructure was awarded in November, 1903, the final connections of the main spans have very recently been made completing the difficult and critical part of the work, and the erection of the viaduct, painting, riveting and minor operations are being pushed as rapidly as possible.

The five large spans are notable for their dimensions and capacity; for the design of the main vertical post nearly 200 ft. high; for the use of nickle steel in the very large eye-bars; for the detailing of pin-connected members of unprecedented magnitude; for the special anchorage adjustments and connections between the cantilever arms, and for many novel and important features in the method and plant developed for their erection. A general elevation and cross section was published in The Engineering Record of March 4, 1905, and details of the island span May 20, 27 and June 10, 1903. The types of the trusses, construction of members and details of connection are substantially the same in the cantilever arms and anchor arms as in the island span, except that the bottom chords in the extremities of the former are radically different on account of their greatly diminished cross section and for the changes due to the varying dimensions and stresses.

The channel spans are symmetrical about their center points as regards their general dimensions and design, but the opposite arms of the same spans are not duplicates on account of the different stresses and deflections developed in the island span and in the shore anchor arms respectively. The most interesting features in the channel spans are the novel details for the connection of the adjacent ends of the cantilever arm designed to afford continuity for the roadways and railroad tracks; to provide for the transmission of lateral stresses, permit independent deflection and temperature movements, and secure accurate adjustment and connection of the members in the field.

The panel points of the main trusses are numbered consecutively from 1 at Pier M. New York anchorage, to 123 at Pier Q, Queens anchorage, the 1,182-ft. west channel span extending from panel point 17 on Pier I to panel point 57 on Pier II, and the east channel span from panel point 75 on Pier III to panel point 107 on Pier IV. The cantilever arms of the two spans meet at panel points 37 and 91 in the centers of the spans.

The connections between the cantilevers at the centers of the spans are exactly similar at points 37 and 91, but the end panels of the two trusses meeting at each of these two points, although symmetrical in outline, are really different, the top chord in one truss and the bottom chord in the other truss terminating one panel distant from the center point and false members are introduced in the two panels to preserve the symmetry of outline and to provide the floor system and horizontal bracing. The true members of the main trusses are shown by full, heavy lines in the small diagram while the false members are indicated by dotted lines.

It is obvious that the members in the parallelogram U35, U37, L39 and L37 are not essential to the integrity of either cantilever truss but are special members introduced to provide for the connections of the two cantilever arms and to secure continuity in the floor platforms and in the transmission of horizontal stresses from one arm to the other. The cantilever arms are connected through the vertical post L37, U37 and the top chord sections U35, U37 and bottom chord sections L37, L39 respectively are superfluous as far as the integrity of the trusses are concerned.

Ambiguity of stresses is prevented by making a positive clearance of 9 in. at L37, between chord sections L35, L37, and L37, L39, and by making a telescopic joint at U37 between top sections, U35, U37 and U37, U39. The two cantilever trusses are connected by the vertical post U37, L37, through adjustable pins provided with a small vertical movement to compensate for irregularities in materials, workmanship or erection and provide adjustment for the final connection in this panel.

Rocker post U37 L37, 51 ft. long over all, is made with two 24 x ½-in. web plates and four 6 x 3½ x 9/16-in. flange angles. In each end there are secured a pair of steel rocker castings, each of which has a finished bearing for a cast-steel horizontal wedge operated by a horizontal screw rod 2½ in. in diameter which passes through it and through the flanges of the casting and is commanded by nuts which enable it to be set and locked in any required position. The beveled faces of the wedges engage phosphor bronze castings with semi-circular bearings for the 10-in. pins which connect the vertical rocker post to the top and bottom chords.

The wedges have a travel of 3 in. corresponding with a vertical displacement of ⅜ of an inch for each pin, thus affording a total adjustment of ¾ in. between the centers of the top and bottom chords and enabling the members to be connected in approximate position and afterwards set exactly by the operation of the end nuts on the 2½-in. screws commanded by a special socket wrench. This wrench has a stem of extra heavy 3-in. hydraulic pipe 5½ ft. long with a cast-steel socket on one end to engage the nut, and a cast-steel sleeve at the other end with a hexagonal shoulder to fit an ordinary open-jaw lever wrench. The long stem enables the nut to be engaged in the otherwise inaccessible position in the plane of the truss and gives room for the operation of a lever at a sufficient distance from the panel point to provide clearance for its movement.

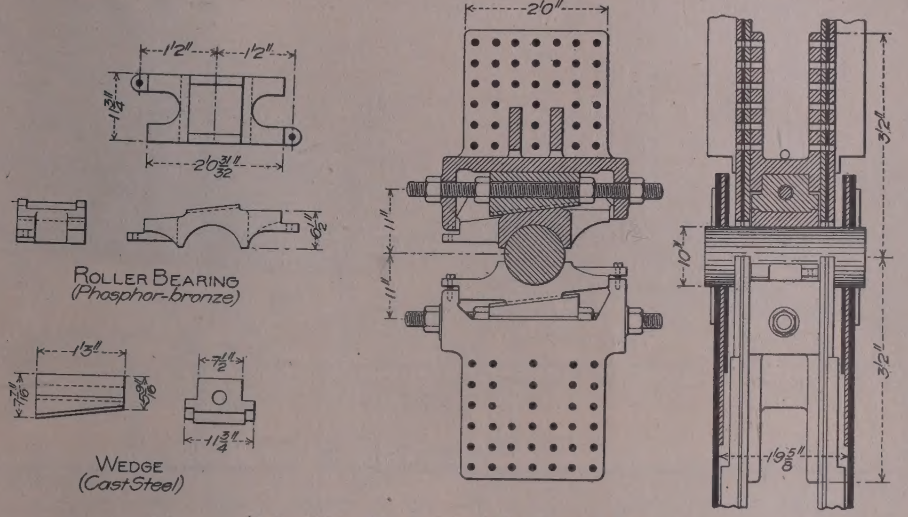
View of Five Main Spans, Looking Upstream.

The top chord, Section U37, U39, is about 39 ft. long over all and is made with two 24 x ½-in. web plates and four 6 x 4 x ½-in. flange angles and is field riveted through web and flange cover splice plates to the adjacent top chord section near panel point U39. The webs are connected by several vertical transverse diaphragms, the flanges are latticed and at U37 there are riveted to the web plates a pair of 83 x 1-in. x 9 ft. 9½-in. vertical connection plates forming jaws which not only provide connections for the end diagonal post and the vertical rocker post but extend beyond the center of the latter, making the telescopic connection for the top chord and diagonal member at the end of the adjacent cantilever truss. The outer edges of the plates are connected by a vertical diaphragm and a transverse horizontal angle forming a seat to receive the weight of the sliding top chord. As the end diagonal U37, L39 is an essential member of the cantilever truss the field connection for it is made with 154 rivets driven after the members are assembled.

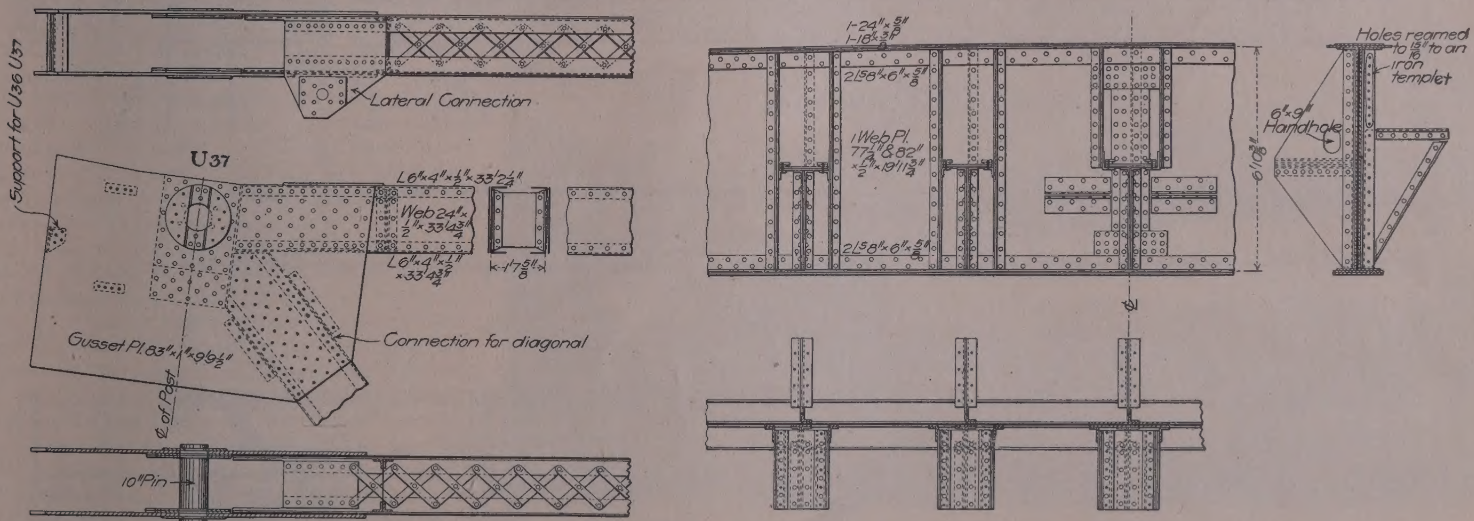
Top chord U35, U37, of the adjacent cantilever arm is, as already noted, a false member subject to comparatively small stresses, but is of similar construction to U37, U39, and has a rectangular cross section made with two 24 x ½-in. web plates and four 6 x 4 x ½-in. flange angles turned in and latticed. At U-37, a short offset conection is provided to receive the upper end of the false sub-diagonal, U37, C36, and the outside rivet heads at the end are countersunk to provide smooth, vertical, exterior surfaces for the telescopic joints between the connection plates at the extremity of U37, U39. In the latter member finished bronze bearing plates are riveted to the in-sides of the connection plates to engage U35, U37 with a clearance of about ⅛ in. and diminish the friction due to its longitudinal horizontal motion.

Lower chord, L35, L37, is an essential member of the cantilever truss and has at L37, wide vertical web plates bored for connection with the vertical rocker post and extending beyond the chord flanges to provide jaw plates for the field-riveted connection to the main diagonal L37, U35. The chord is about 38 ft. long over all, spliced at one end with field-riveted web and flange cover plates and having at the opposite end a clearance of 9 in. with false lower chord L37, L39. It is made with four 8 x 6 x ½-in. flange angles turned in and latticed and has two webs each made with a pair of 48 x 3/16-in. plates riveted together with 11 horizontal lines of rivets. The webs are connected by vertical transverse diaphragm plates at panel and sub-panel points.

The false bottom chord, L37, L39 resembles L35, L37 but is of much lighter construction and has no conection whatever with the latter or with the vertical rocker post. The extremity is braced for horizontal shear only through the lower end lateral strut which corresponds with that for L35, L37 and is connected to the latter on the center line of the bridge.

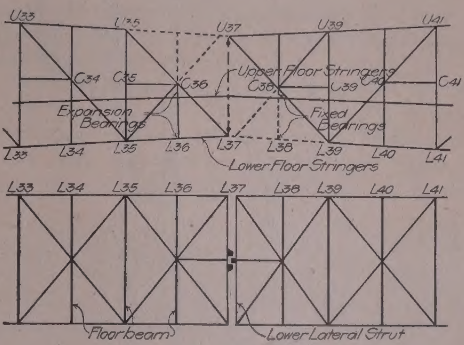


Adjustable Pin Bearings for Center Post.



Part of Top Chord, U37-U38, and Center Lower Floorbeam, L37-L37.

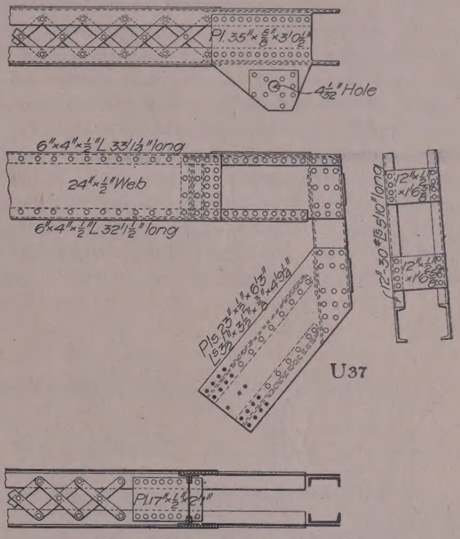
Main diagonals U37 and L39 and the false diagonals, U35, L37 are of very simple construction with rectangular cross sections built up with 24 x ¾-in. web plates and 6 x 4-in. flange angles turned in and latticed and are field-riveted at both ends to the top and bottom chord connection plates. The hangers L36 support the lower chords L35 and L37 at their middle points and are similar to the corresponding members in other points of the truss and pairs of 72 x ¾-in. x 10-ft. 8-in. jaw-plates, are riveted to the upper ends of the members to form connection plates for all of the web members of the truss intersecting at C36 and the members are shipped from the bridge shop with open holes in the inner flanges for the field-riveted connections of the upper and lower floor beams. Slotted holes are also provided through the lower parts of the hangers to allow for the tension connections between the main floor beams and their cantilever connections.



Main Trusses and Lower Lateral System at Center of Cantilever Span.

The transverse bracing at panel point 37 consists of a portal strut connecting top chords U37 and U37 in both trusses and rocker posts U37,L37 and a pair of horizontal transverse struts, one of which connects bottom chords L36, L37 and the other connects bottom chords L37, L38 in both trusses at point L37. The top chord strut is a sort of box lattice girder of rectangular cross section 3 ft. deep in the center and about 14 ft. deep at the ends made with a pair of horizontal top flange angles 20 in. apart and a pair of curved bottom flange angles connected by zig-zag angles in vertical planes and by crossed lattice bars on their horizontal flanges. At intermediate panel points the upper transverse struts have a rectangular cross section about 3½ ft. wide with a uniform depth of 9½ ft., and are made with four 4 x 4 x ½-in. corner flange angles. Each angle is reinforced by a full-length 8 x ⅞-in. horizontal plate. The vertical faces of the struts are latticed with single 3½ x 3½-in. angles and the horizontal faces with 3 x ⅝-in. flat bars.

The top lateral diagonals are made throughout with square rods having clevis ends attached to wing plates at panel points. Except at panel points L37 and L91 where there are special transverse struts, the lower floor beams serve for lateral struts and the bottom lateral diagonals are everywhere I-shaped members about 28 in. deep made with pairs of angles riveted together back to back and latticed. They extend across two panels and are field-riveted at the extremities between horizontal jaw-plates, which, on the center line of the bridge, are riveted to the lower flanges and to the webs of the floor beams.

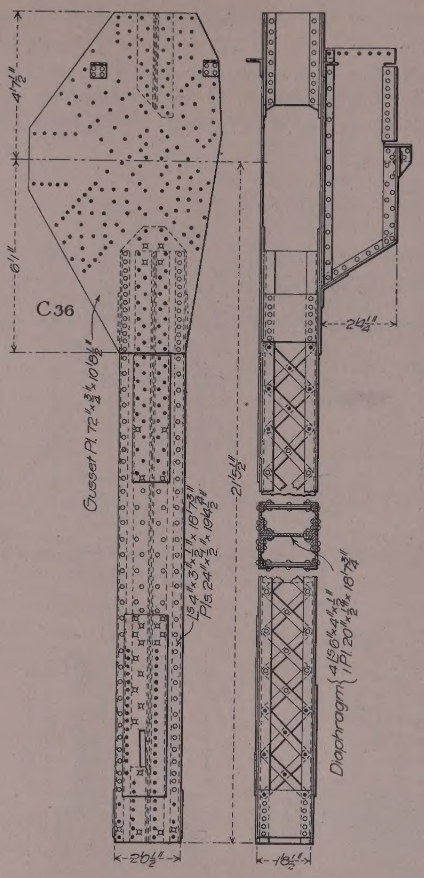


End of Top Chord, U36-U37.

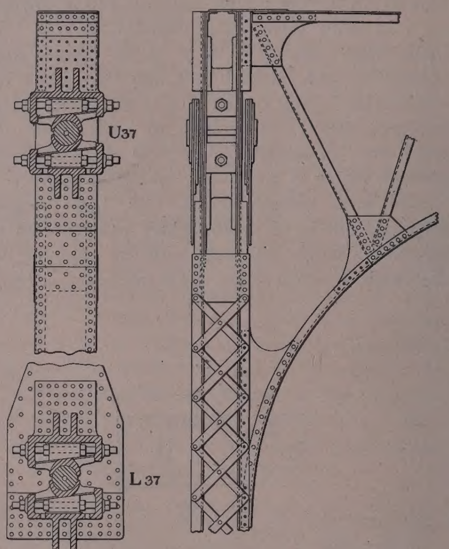
The bottom chords L35, L37 in opposite trusses are connected by a floor beam at L37 and by one horizontal transverse strut L37L37, which receives the lateral stresses from the diagonal members and transmits them to the adjacent cantilever arm to the corresponding strut L37L37, which connects the extremities of the false bottom chords L37, L39 in opposite trusses. Both struts have rectangular cross sections made with two 28 x ½-in. web plates, 28½ in. apart and four 6 x 6 x ⅝-in. flange angles latticed with 6 x 4-in. zig-zag angles. The end sections of the web plates project above the top flanges of the struts to form deep vertical connections with the bottom chords, and both struts have horizontal extensions on one side at the center to provide for the transmission of transverse stresses and permit longitudinal without lateral motion.

Wide plates ½ in. thick are riveted across the top and bottom flanges of the strut to form two pairs of jaws on one strut engaging a single pair of jaws on the other strut. The double jaws project nearly 3 ft. toward the center of the bridge beyond the flanges of the strut and their outer edges are stiffened by flange angles and connected with vertical longitudinal and transverse diaphragms of the full depth of the strut. Grooved castings are riveted to the inner longitudinal vertical plates and receive vertical planed strips for bearing on the sliding surface of the other strut. The jaw plates which project from the center of one strut between the double jaws in the other strut are reinforced by horizontal stiffener angles transverse to the bridge axis and have their outer edges connected by vertical longitudinal plates planed and countersunk riveted so as to fit close and slide smoothly against the bearing strip above described in the opposite jaws. This arrangement provides for longitudinal displacement without vertical or transverse motion and transmits the shear from one cantilever to the other.

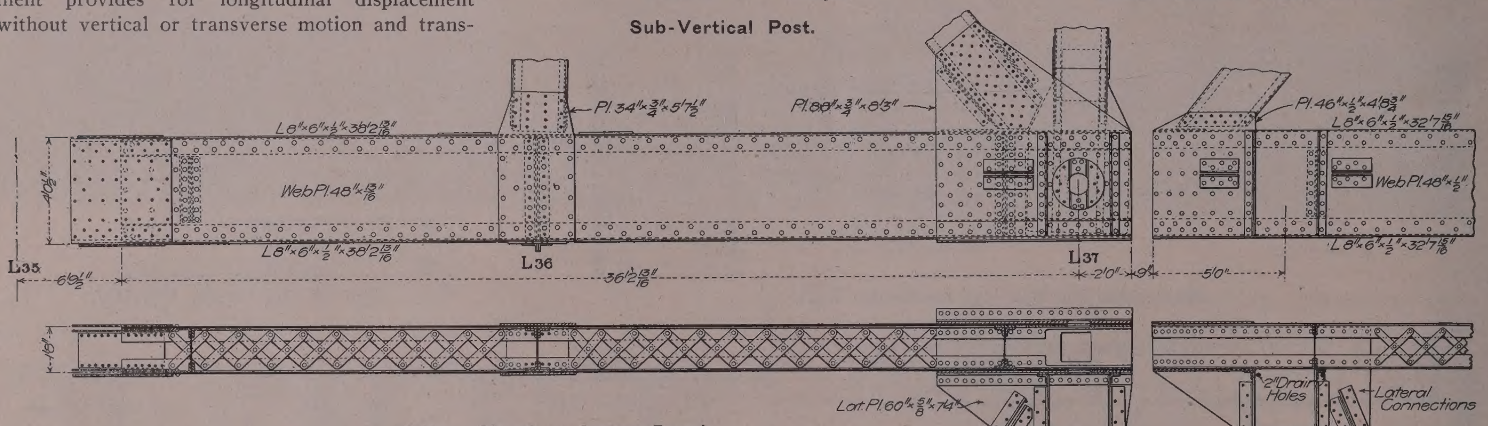
The regular stringers in the lower deck are one panel long and are web-connected to the floor beams at every panel point. The stringers are web-connected in the usual way to floor beams L38, and at L36 they are not bolted or riveted but have planed sole plates sliding in pockets which project about 2 ft. 9 in. beyond the center of the floor beam. The pockets are made with pairs of vertical side plates of the full depth of the floor beam and parallel to the bridge axis 19¼ in. apart, which are riveted to the vertical web-stiffener angles in the floor beams. They support double thicknesses of horizontal seat plates provided on the upper surface with cleats to engage the bottom flanges of the stringers and take bearing in the planes of the stringer webs on the top flanges of solid plate brackets transmitting the loads directly to the floor beam webs. Opposite each pocket a wide single web bracket is riveted to the floor beam web to receive the fixed end of the regular stringer. The pocket for the center stringer differs from those above described



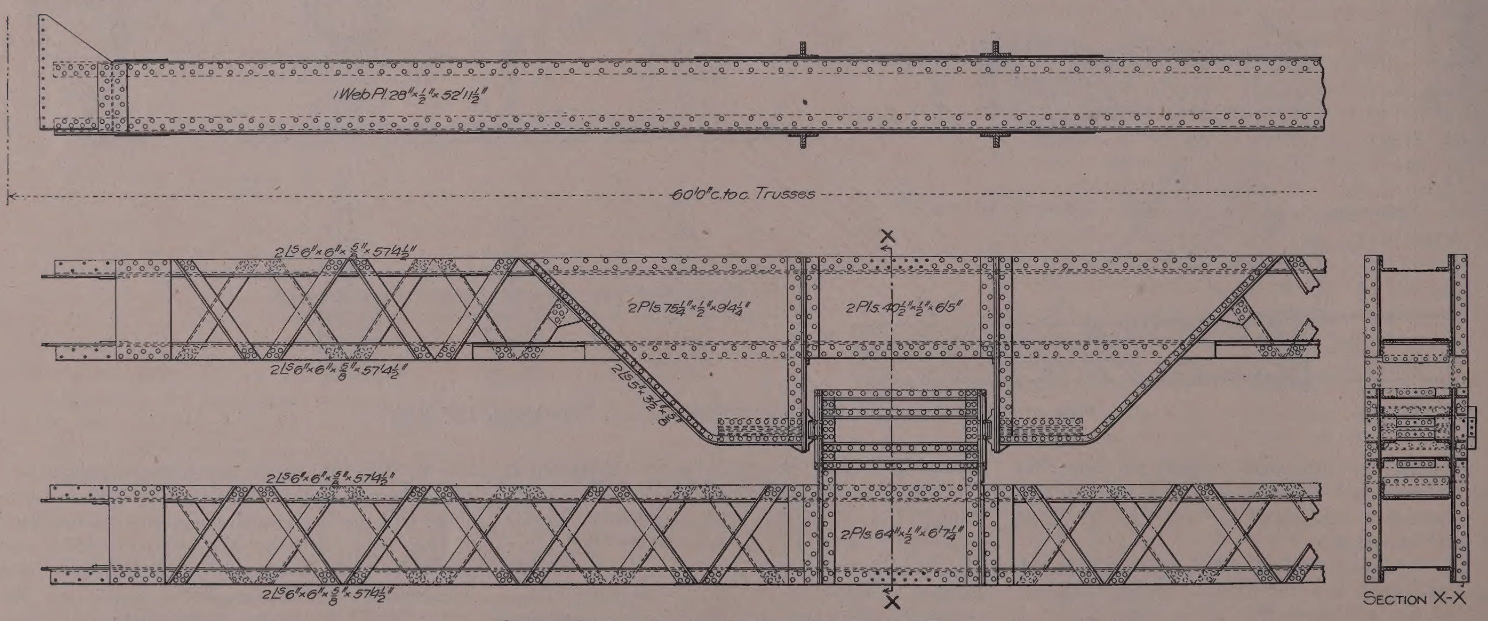
Sub-Vertical Post.



Center Vertical Post, U37-L37.



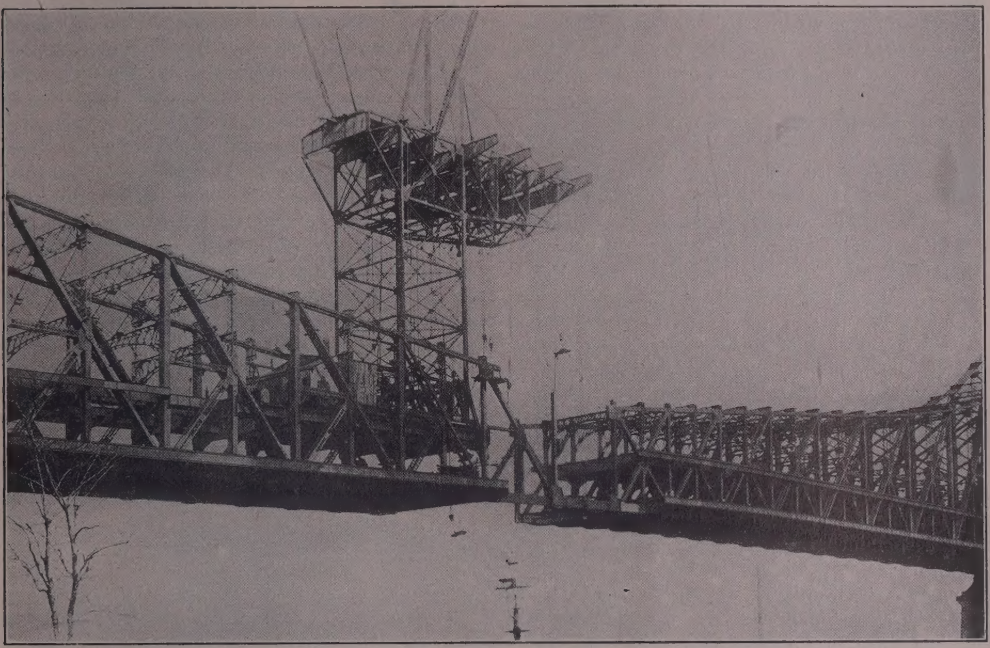
Bottom Chord of Center Panel.



Connections of Lower Lateral Struts at L37.

in that the side plates terminate near the center line of the floor beam to clear the horizontal angles riveted to the web of the latter for the connection with the lower lateral diagonal struts. The floor beam is about 68 ft. long and 7 ft. deep over all and receives eleven lines of stringers.

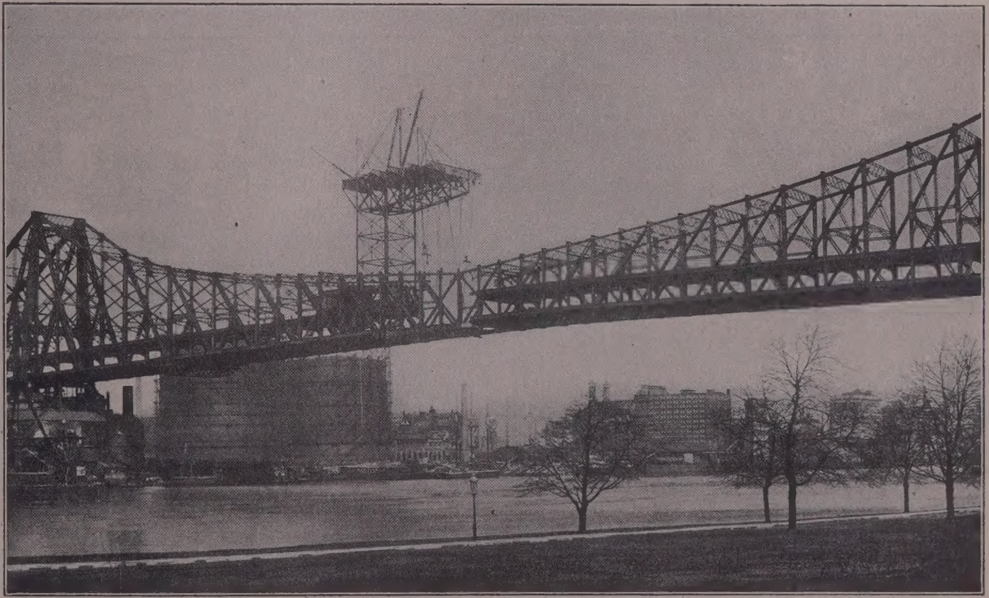
The upper floor expansion joint at L36 corresponds with that in the lower floor except in the dimensions of the stringers and in the connections at the end of the latter. The floor beam is about 6½ ft. deep over all and receives eight lines of stringers but has no lateral connection. The stringers are all 3½ ft. deep and on one side are riveted to the single web bracket and on the opposite side are seated loose in the pocket. In both cases, however, the bottom flanges take bearing on plain filler plates tapered 13/32 in. in one foot to correspond with the grade of the track.



Connecting the 984-Foot East Channel Span.

The erections of the west and east channel spans weighing respectively about 7000 and 5000 tons were commenced nearly simultaneously from island piers II and III, with the No. 2 travelers described in previous articles, which moved out over the river as soon as they had completed the erection of the upper part of the island span. Each traveler was of the Z-shape type which has been adopted for recent long span cantilever bridges in this country, had a tower 120 ft. high and with its equipment of one 65-ton derrick, 34 sets of heavy tackles and two hoisting engines and stores, weighed about 625 tons and was operated by a crew of about 60 men. The travelers moved between the trusses on the upper deck and completed the erection of all principal members as they advanced until they reached the extremities of the cantilevers and were taken down by auxiliary derricks, transferred to the opposite shores, reassembled on the anchor arms and advanced over the river, erecting the shore arms of the cantilever spans at the rate of about 2000 tons per month for each traveler, as described in The Engineering Record of March 2, June 8 and 15, 1907.

The travelers reached their final position at panel point 33 and 95 about the 1st of March last, when careful measurements and observations were taken to verify the elevations and alignments of the trusses and secure accurate dimensions for the preliminary adjustment necessary for the assembling of the members in the last panel and the connections of the adjacent cantilevers. At this time the island cantilevers sustained nearly their full dead load except roadway flooring, rails, railings and sidewalk slabs, while there still remained about 1000 tons of material to be added to each of the shore cantilevers, amounts which were partly offset by the concentrated traveler loads near their extremities. These conditions had been foreseen and the shore anchorages arranged so that the elevation at the ends of the cantilevers corresponded very closely and the lateral alignment was so accurate that no changes were necessary and the final connections were made without any difficulty or alterations.



Connecting the 1182-Foot West Channel Span.

As the bottom chords were assembled before the other members of the end panels and as they prevented the first and most striking appearance of a connection between the two great arms, it was officially announced that their erection would constitute the closing of the span and considerable publicity attached to the operation which was performed March 18th, for the 984-ft. east span, in the presence of the principal officials of the city, the Bridge Department, contractors and guests. The corresponding connections were made for the 482-ft. west span on March 12th, thus safely completing the critical work and successfully transforming the huge unfinished cantilever to a stable integral part of the great continuous span with greatly increased resistance to storm and wind pressure.

The bottom chord pieces L91 L95, four panels or about 88 ft. long, weighed 30 tons each were suspended in position from the traveler. The vertical posts L91, U91, already in position and connected at the top, were then connected to the bottom chords of the adjacent cantilevers by temporary wooden pins called toggles, and the first crossing was made from shore to shore over them on light temporary platforms protected by hand rails. Afterwards the remaining members of the trusses and of the floor and lateral systems were erected and the demolition of the traveler commenced. The erection of the sidewalk stringers, hand rails and other minor members is being rapidly advanced, field rivets are being driven in the lower chords and floor beam connections of the shore arm cantilevers, and all of the field rivets are following up the cantilevers on the main spans and employing from 20 to 30 gangs of riveters. Painting and other finishing work is in progress, and the steel falsework under the anchor arms having been entirely released is being removed by tackles suspended on the finished structure and will be cut up for scrap. A total force of about 500 men is now employed on the superstructure of the main spans besides a force nearly as large at work on the erection of the viaduct approaches at both ends of the bridge.

The appearance of the bridge crossing both river and the island, high above roofs, trees and city, is very impressive and its importance as another artery for the enormous traffic between the two cities cannot be over-estimated. The principal dates in the calendar of the superstructure are, commencement of erection of island spans, Sept. 9, 1905; completion of island spans, Dec. 4, 1906. Completion of first island cantilever, April 13, 1907; completion of first shore cantilever, March 12, 1908, and completion of second shore cantilever and connection of entire main superstructure, March 18, 1908. Considerable time has been lost on account of bad weather and labor trouble.

The dimensions of the members erected have been limited only by the facilities for manufacture and transportation. A large amount of costly special plant has been designed and installed for the erection, new methods have been devised and executed and the rapidity and success of the construction, unmarred by any serious accidents or delay, reflect the highest credit on the courage, ability and devotion of the engineers and contractors who have planned, detailed, fabricated, supervised and erected the great structure. Special pains were taken to adapt the details of the superstructure and its connections not only to their most perfect and economical function in the finished structure, but as well to advantageous fabrication by mill and shop machinery and to the facility, safety and rapidity of erection. The success of these efforts, the precision of the computations and the accuracy of the workmanship are proved by the successful erection.

The bridge was designed and its construction and erection supervised by the Department of Bridges, New York City, Mr. James W. Stevenson, commissioner, Mr. C. M. Ingersoll, Jr., chief engineer, Mr. Austin Lord Bowman, consulting engineer, Mr. J. D. Wilkins, engineer in charge and Mr. J. A. Knighton, engineer of construction. Messrs. Ryan and Parker were the contractors for the main piers, and the superstructure of the five main spans was fabricated and erected by the Pennsylvania Steel Co.

Water and Sewage Purification Legislation in Ohio.

On March 26, the Ohio General Assembly passed the following bill authorizing the State Board of Health to require the purification of sewage and public water supplies and to protect streams against pollution.

Section 1.—Whenever the council, or Board of Health of any city or village, or the commissioners of any county, or the trustees of any township make complaint in writing to the State Board of Health, setting forth that a city, or village or corporation or person is discharging or permitting to be discharged any sewage or other wastes into any stream, water course, lake or pond and is thereby creating a public nuisance detrimental to health or comfort, or is polluting the source of any public water supply, it shall be the duty of the State Board of Health to forthwith inquire into and investigate the conditions complained of; and whenever the State Board of Health finds after investigation that the source of public water supply of any city, village or community in this state is being subject to contamination or has been rendered impure by reason of the discharge of sewage or other wastes, or in any other manner by any city, village, corporation or person; or whenever said Board finds that such sewage or other wastes have so corrupted any stream, water course, lake or pond as to give rise to foul and noxious odors, or to conditions detrimental to the health or comfort of those residing in the vicinity of such stream, water course, lake or pond, it shall notify such city, village, corporation or person causing the contamination or pollution of any such stream, water course, lake or pond of its findings and give them an opportunity to be heard, and after such hearing if the State Board of Health determines that improvements or changes are necessary and should be made, it shall report its finding to the Governor and Attorney General, and upon their approval said Board shall notify such city, village, corporation or person to install such works or means satisfactory to said Board, for purifying or otherwise disposing of its sewage or other wastes, or to change or enlarge existing works in a manner to be satisfactory to said Board; such works or means must be completed and put into operation within a time to be fixed by said Board, which time shall be subject to the approval of the Governor and Attorney General. Provided that no city or village that is now discharging sewage into any river which separates the state of Ohio from another state shall be required to install sewage purification works as long as the unpurified sewage of cities or villages in any other state is discharged into said river above said Ohio city or village.

Section 2.—Whenever the Board of Health or Health Officer of any city or village, or ten per cent of the electors thereof, file with the State Board of Health a complaint in writing, setting forth that it is believed that the public water supply of such city or village is impure and dangerous to health, it shall be the duty of the State Board of Health to forthwith inquire into and investigate the conditions complained of; and whenever the State Board of Health finds after investigation, that the public water supply of any city or village is impure and dangerous to health and that it is not practicable to sufficiently improve the character of such supply by removing the source or sources of pollution affecting it, or if said Board finds that such water supply is being rendered impure by reason of improper construction or inadequate size of existing water purification works, it shall notify such city, village, corporation or person owning or operating such water supply of its findings and give them an opportunity to be heard, and after such hearing if the State Board of Health determines that improvements or changes are necessary and should be made, it shall report its findings to the Governor and Attorney General, and upon their approval said Board shall notify such city, village, corporation or person owning or operating such water supply to change the source of supply or to install and place in operation water purification works or device satisfactory to said Board, or to change or enlarge existing water purification works in a manner satisfactory to said Board, within a time to be fixed by said Board, which time shall be subject to the approval of the Governor and Attorney General.

Section 3.—Whenever the State Board of Health finds, upon investigation, that any water or sewage purification works, on account of incompetent supervision or inefficient operation, is not producing an effluent as pure as might reasonably be obtained from such plant, and by reason of which any public water supply has become dangerous to health, or any stream or body of water has become offensively polluted, or has become a public nuisance, said Board shall issue an order to the officer, board or department of any city or village, or the corporation or person having charge of or owning such plant, to secure an effluent as pure as might be reasonably expected from such plant and satisfactory to said Board; and if such officer, board or department of any city or village, or such corporation or person fails, for a period of five days after receiving such order, to secure such an effluent, the State Board of Health shall report the fact to the Governor and Attorney General and upon their approval may order such officer, board or department, or owner of such plant, to appoint within ten days, and pay the salary of, a competent person, to be approved by said State Board of Health, to take charge of and operate such works so as to secure the results demanded by the State Board of Health.

Section 4.—If in any case any order of the State Board of Health, when approved by the Governor and Attorney General, and made in pursuance to the provisions of this act, is not acceptable to any city, village, corporation or owner affected thereby, such city, village, corporation or owner shall have the right of appeal as follows, to-wit: The necessity for and reasonableness of such order may be submitted to two reputable and experienced sanitary engineers, one to be chosen by the city, village, corporation or owner to which such order of the State Board of Health applies, and the other chosen by the State Board of Health, who shall not be regularly employed by said Board, and who shall act as referee engineers. If the engineers so chosen are unable to agree then they shall choose a third engineer of like standing, and the vote of the majority shall be final and binding. The referee engineers, herein provided for, shall have power to affirm, modify, or reject, the order of the State Board of Health submitted to them, and their decision, as reported in writing to the Governor and Attorney General, which shall be rendered within a reasonable time, shall be accepted by the State Board of Health, and shall be enforced by said Board in the manner provided for in this act. The fees and expenses of said referee engineers shall be equally divided between the city, village, corporation or owner requesting such reference and the State Board of Health.

Section 5.—It shall be the duty of every such municipal council, department or officer having jurisdiction, to provide for the raising of revenues by tax levies, sale of bonds, or otherwise to take all steps necessary to secure the funds for any such purpose or purposes; and when so secured, or the bonds thereof have been authorized by the proper municipal authority, the same shall be considered as in the treasury and appropriated for such particular purpose or purposes, and cannot be used for any other purpose; provided, that the bonds herein authorized to be issued for the purposes enumerated in this act shall not exceed five per cent of the total value of all property in any city or village, as listed and assessed for taxation, which may be in addition to the total bonded indebtedness allowable under the provisions of section 2835 of the Revised Statutes, but the question of the issuance of such bonds shall not be required to be submitted to a vote.

Section 6.—If any council, department or officer of any municipality, or person or private corporation, shall fail or refuse for a period of thirty days after notice given him or them by the State Board of Health of its findings and the approval thereof by the Governor and Attorney General of the state of Ohio, to do and perform any act or acts required of him or them to be done and performed by this act, such members of council or department, and such officer or officers, or person or private corporation shall be and become personally liable for such default, and upon conviction thereof shall forfeit and pay to the State Board of Health $500 to be deposited with the state treasurer to the credit of said board; provided, however, that the Governor and Attorney General, upon good cause shown, may, in their discretion, remit said penalty, or any part thereof.

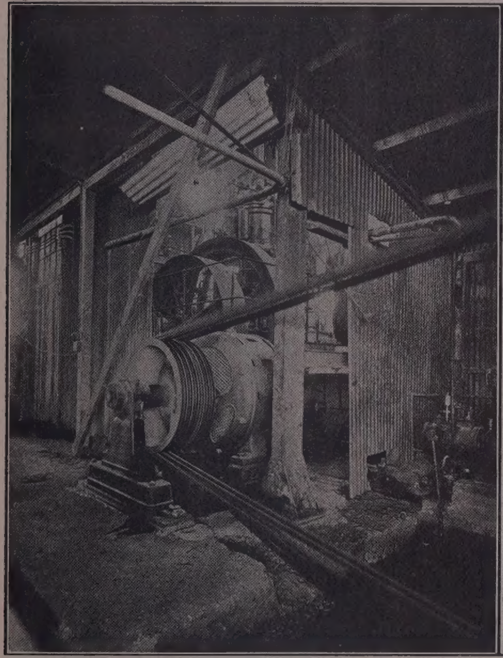
Section 7.—An action may be begun for the recovery of any such penalty by the prosecuting attorney of any county in the name of the state of Ohio in the court of common pleas of such county having jurisdiction of any such party or parties; or it may be begun by the Attorney General in any such county or in the county of Franklin, as provided for by sections 210 and 211 of the Revised Statutes of Ohio.

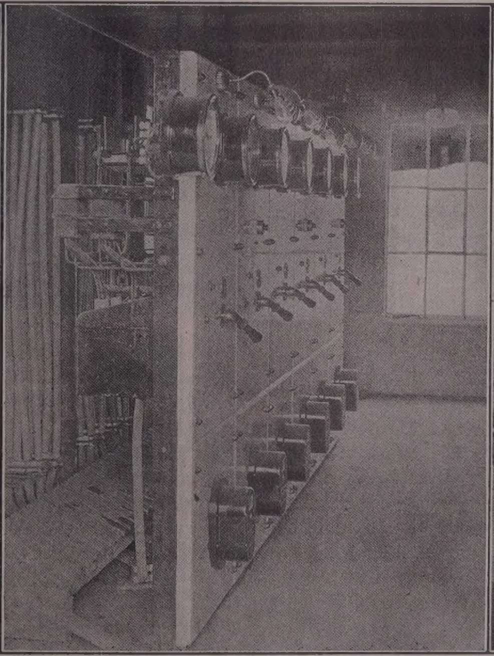
The Port of St. John, N. B., has a tidal rise and fall of 20 to 25 ft., while just above the harbor the tidal variation is reduced to 2 to 5 ft., by a dike or sill of hard rock, 15 to 20 ft. below the water level, across the narrowest spot of the channel. At the present time the port facilities are confined to the location having the large tidal variation, and since harbor space is becoming cramped, a method of utilizing a portion of the River St. John and the Kennebecasis Bay, having the small tidal variation of only 2 to 5 ft., was recently proposed in a paper before the Canadian Society of Civil Engineers by Mr. J. S. Armstrong. The scheme suggested is the construction of a large canal about 1400 ft. long, cutting across a promontory, round which the river now winds, from the present harbor to the River St. John, well above the "Reversing Falls" due to the sill of hard rock. The site above the falls affords good dock facilities with deep water close into the banks, while in one part, convenient to the railroad, the banks are high enough to permit the building of shipping wharves for coal and grain without the construction of long approach grades. An additional advantage is the fact that this stretch of water freezes only lightly in winter and can easily be kept open. Locks would, of course, be necessary in the canal.

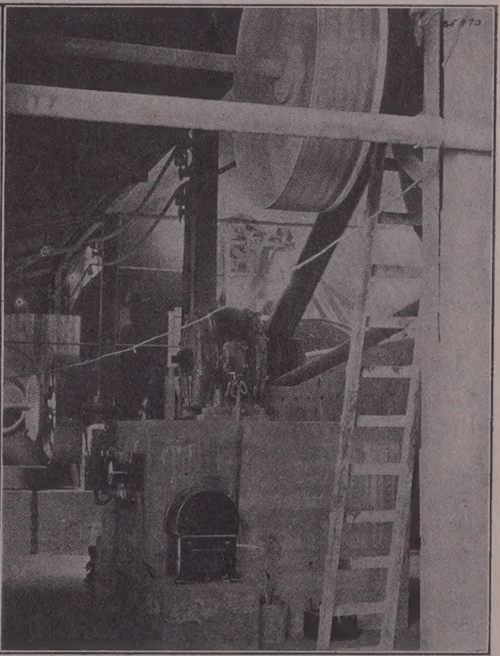
An English Electrically-Driven Cement Works.

The important Portland cement works of Messrs. Casebourne & Co., Ltd., are situated at Haverton Hill, on the north bank of the Tees, and cover an area of about 5¼ acres. They are extremely compact, and are built almost entirely on foundations of reinforced concrete owing to the marshy nature of the site. Until recently the entire cement-making machinery was driven by oil engines, which have now been superseded by three-phase induction motors. The directors of the company first considered the subject of electrically driving their works at the beginning of last year, and after due deliberation were satisfied that the change-over would increase their output and cheapen their cost of production. A contract was therefore entered into for a generating plant, but this was subsequently cancelled in favor of an arrangement effected with the Cleveland & Durham Electric Power Co. for a supply of energy direct. Thus, motors and switchgear alone became necessary, and the contract for these was awarded to the British Westinghouse Electric & Mfg. Company, Ltd., of Manchester and London. As the Cleveland & Durham Electric Power Co. generates and supplies current at a price per unit which is said to be unequalled in Great Britain outside the Newcastle area, Messrs. Casebourne's choice of means for obtaining a supply was fully justified. The installation is particularly interesting as being the first cement plant in England to be electrically-driven throughout.

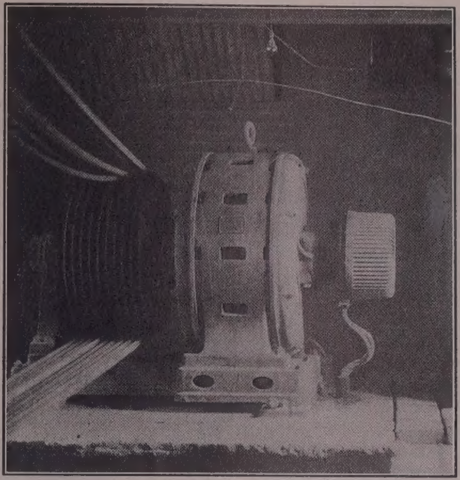
In operating modern cement-making machinery an absolute continuity of motive-power is essential. The old system by which Messrs. Casebourne's machinery was driven cannot be said to have met this condition, as the oil engines had an unfortunate way of breaking down. Also, the practice of mechanically transmitting power from a central source is, of course, open to such objections as the loss in long lines of shafting, lack of flexibility, and the necessity for large floor space conforming to engine requirements.


Motor for Wet Mills.


Low-Tension Switchboard.


Motor for Warehouse Conveyors.

The various processes through which the raw material, chalk and clay passes before it emerges as the finished product, are as follows: In the first place, the chalk is brought by sea from Kent, up the river Tees, in steamers loading about 1,000 tons, to the side of Messrs. Casebourne's jetty. Here it is hoisted from the boats by means of grabs, and emptied into the hoppers of two large elevated crushers, through which it passes into a "Hunt" bucket-conveyor, made by Babcock & Wilcox. This conveyor is driven by a 20-h.-p. motor, and each bucket is swung on a center pivot, and travels to the end of a raised gantry, where it is tipped. The chalk falls near the wet-mill, into which department it is run in bogies and emptied into wash-mills. The clay, which is dug locally, is brought in wagons, and also emptied into the wash mills, the proportion of chalk to clay being approximately as three to one. These wash mills are octagonal in shape, and are fitted with harrows, which are attached to radial arms, and rotated by a central vertical shaft. Water is kept constantly flowing into them, and combines with the chalk and clay until the mixture is in a liquid form, termed slurry. This slurry is then taken by a bucket elevator into the slurry-grinding or tube mills, situated immediately behind the wash mills. In passing through the tube mill the slurry is very finely ground, and it is recognized as one of the all-important points in cement manufacture, that the finer the slurry the more reliable and constant in volume will be the cement. From the tube mills the slurry is pumped through underground pipes, by means of a three-throw 10-in. pump, into a large reinforced-concrete mixer, holding about 900 tons. The continual rotation of large arms inside the mixer keeps the slurry at an even consistency before it enters the rotary kilns.


200-H.-P. Motor Driving Ball and Tube Mills.

It is next lifted, by a second pump, from the mixer up to the nose or entrance of each of the four 100 x 6½-ft. rotary kilns, using powdered coal. The clinker falls through a hood, at the lower end of each kiln, into a rotating clinker-cooler, in which it is cooled by cold air. Sliding down this cooler by gravity, it next falls into a shaker conveyor, which transfers it to an inclined bucket-elevator, by which it is discharged into an elevated 300-ton, reinforced-concrete bin, situated over the dry-mill. In this silo the clinker divides, and drops down two shoots into a pair of Krupp ball-mills for preliminary grinding, from which it proceeds by a bucket-elevator into an Avery automatic-weigher. The partially-ground material now passes by an inclined screw-conveyor into two 26 ft. 4 in. by 5 ft. Krupp tube-mills, in which the final grinding is done. On emerging from the dry tube-mills the finished cement is taken by means of a screw-conveyor, an elevator, and a second screw-conveyor into the packing warehouse, where it falls down specially-designed shoots. The warehouse holds 6,000 tons of finished cement, which is sacked off for shipment by rail or water.

The coal is brought in wagons along a siding and tipped into a large, circular ferro-concrete coal pit, from which it is elevated into a rotary coal-dryer, heated by hot air. The coal, on leaving the dryer, should not contain more than about 1 per cent. of moisture, or it fails to grind perfectly, which operation is performed by two ball-mills and two tube-mills, similar in principle to those already referred to for grinding the clinker. The finely-ground coal is then transferred by a screw-conveyor to four 5-ton hoppers, at the end of the kiln house, where it next passes to the coal-feed fans, which blow it into the kilns, the amount of feed for each kiln being regulated by a Reeves variable-speed gear. A stream of hot air from the clinker coolers furnishes the supply of air for the fans, and gives a still further drying effect to the fuel.

The new electrical scheme, together with certain mechanical improvements of considerable importance, has been carried out under the supervision of Mr. W. J. Coles, of Messrs. Maxted, Knott & Coles, of Hull, the consulting engineers.

The three-phase, 40-period, high-tension transmission lines of the Cleveland & Durham Electric Power Co. are brought from Grangetown, a distance of 13 miles, into a sub-station at the works. The cables are run underground, and it is the intention of the power company to lay a duplicate set to safeguard against accident. The current is then transformed down from 11,000 to 440 volts, the maximum variation of the pressure at the motor terminals being from 400 to 440 volts.

A Westinghouse low-tension switchboard is erected in the sub-station, and consists of six white, Sicilian-marble panels, with fittings of copper finish. Each of the panels is of approximately 150-kw. capacity, and is fitted with an ammeter, an oil-break switch, a lighting arrester, and an integrating wattmeter. The motors controlled from the panels are distributed in the six different sections of the works, and it is easy to calculate from the wattmeter readings the operating expenses of each section. A large integrating wattmeter fixed on the wall immediately facing the switchboard, gives the total consumption of electrical energy from the power mains.

All of the alternating-current motors are of the Westinghouse induction type, and, except three of 50-h.-p. capacity, are provided with wound rotors and slip-rings, so that resistance can be introduced into the rotor circuits when starting. The wash mills and tube mill, in the wet-mill department, are driven by a 200-h.-p. variable-speed motor. They were originally driven by the oil engine seen at the rear, and a comparison of floor space between the old and the new equipment is not without interest. This engine occupies practically 570 sq. ft., while the motor occupies 45 sq. ft. If we are also to include the water-cooling arrangement for the engine, which covers an area of roughly 855 sq. ft., we have a large balance in favor of the electric motor. There is another important advantage afforded by the electric drive in this department. Should the wash mills be shut down for an appreciable period, the slurry practically solidifies around the interior frames, which circumstance, together with the heavy nature of the machinery, makes a large torque at starting essential. As the 200-h.-p. induction motor is designed for a starting torque of not less than twice the full-load running torque, the advantage is obvious. This may also be said of all the motors to which reference is made.

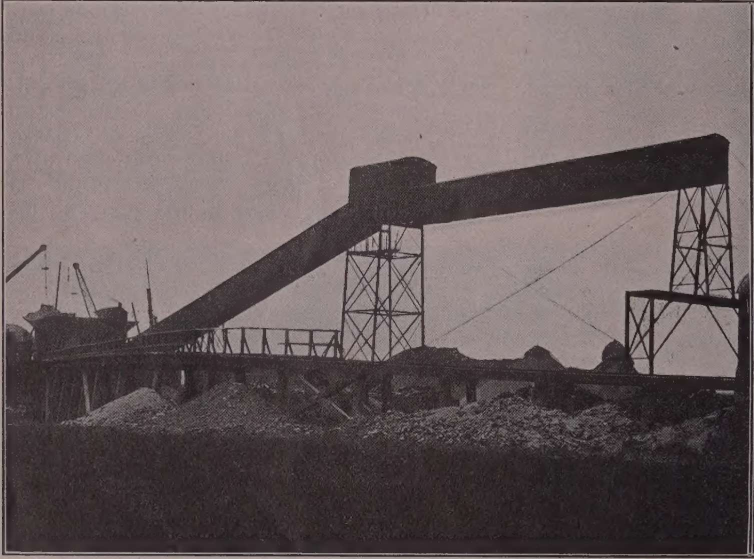
In the rotary-kiln house there are four 15-h.-p. motors, each mounted on a concrete pedestal and driving a rotary kiln, the method of rotating the kiln being by belt drive through spur-reduction gearing. The 15-h.-p. motors are of the variable-speed type, and are capable of giving their full-load torque at any speed between 400 and 800 r.p.m., the motor speed being varied to suit the amount of slurry passing through the kiln. The line shaft in the kiln house is driven by a 100-h.-p. motor, and operates the slurry pumps between the 900-ton mixer and the kilns, the clinker coolers and the shaker conveyor. This latter feeds into an inclined bucket-elevator, operated by a 15-h.-p. induction motor, which leads into the dry mill, where the ball and tube-grinding plant is driven by two 200-h.-p. motors, the mill being originally operated by two large oil engines, still to be seen. The drum-type controller, shown in the illustration of this mill, has nine starting notches, and the current-carrying portions are fitted with cheap copper tips, which may be easily renewed when spark-wear renders this necessary. The screw-conveyors leading from the dry mill to the warehouse are operated by a 50-h.-p. motor, and the coal-crushing plant by a 150-h.-p. motor.

Besides those already referred to, there are two 50-h.-p. motors driving direct-current generators. These latter are for lighting and for supplying direct-current to the 20-h.-p. motor operating the jetty conveyor, a small motor in the chemical laboratory, and one driving the fitting shop.

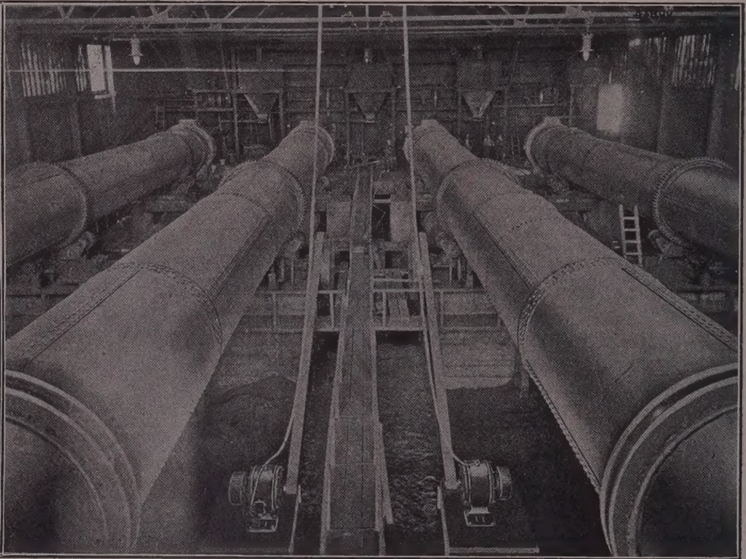
All the alternating-current motors are of the Westinghouse semi-enclosed type, with open stator slots, and coils so arranged as to be readily interchangeable in case of accident; and the design of each stator and rotor is such as to produce a continuous flow of air through the internal parts while running. The guaranteed full-load efficiency of the 200 and 150-h.-p. motors was 92 per cent., of the 100-h.-p. motor 90 per cent., and of the 50 and 15-h.-p. motors 87 per cent. and 85 per cent. respectively.

The aggregate capacity of the motors recently installed is nearly 1,100-h.-p., and it may be of interest to note that from 3½ to 4½ million Board of Trade units will be required per annum, which amount should form a valuable load on the Cleveland Power Co.'s mains.

In electrifying their works Messrs. Casebourne looked for a substitute for the oil engine that would in the main eliminate many of the objectionable features before referred to, as well as provide a source of power immune from fire risk, and which could be sub-divided and applied at the most advantageous points. The natural solution was the adoption of induction motors, and former troubles are now unknown, in spite of many adverse conditions against ideal motor operation. Of the many industrial applications of the electric motor there is probably none where the service demands are more exacting or the operating conditions more severe than in cement works. The heavy torque required to start the cement-making machinery, the nature of the load handled, the constant presence of dust, and the inflammability of pulverized coal, bring problems into the electric drive which require the most experienced calculation. In the face of these facts, however, the advantages which have been afforded by its adoption have greatly extended the manufacturing limits of Messrs. Casebourne.



Bucket Conveyor for Raw Materials.



Interior View of Kiln Room.

An Anemometer and Wind Direction Indicator.

The Hotel St. Regis, an eighteen-story hotel at 5th Ave. and 55th St., is one of the few large buildings in New York City that is heated throughout by the use of the indirect system, and owing to the use of the fan blast system, to the entire exclusion of direct radiation, the facility with which the guests' rooms in various portions of the hotel are heated is noticeably affected by the direction from which the prevailing winds strike the exterior of the building. In the operation of the heating system of the building, inspectors placed in charge of the fresh air supply and heating equipments in the three upper sections of the building served, are required to so adjust the temperature of the air deliveries and the proportions of the supply volumes to the different sides of the various floors, as to equalize as nearly as possible the heating effect in all parts of each floor. The various sections of the tempering coils of these three fan equipments are fitted for hand-control in place of the usual automatic-control from thermostats in the intake and warm air ducts, and the pneumatic push-button controls have been conveniently located for access by the inspectors. These and the other interesting and novel features of the heating and ventilating equipment of this 18-story hotel were fully described in The Engineering Record for Aug. 25, 1906.

In the effort to facilitate the ascertainment of the direction of the prevailing wind and its velocity at all times, an interesting device has been constructed and installed by the chief engineer of the building, Mr. J. C. Jurgenson, which consists of a combined wind vane and anemometer with electrical attachments so arranged as to indicate their readings in the lower part of the building. The value of such an instrument is evident from the fact that while the office of the chief engineer is in the sub-basement of the building and the care of the mechanical equipment is directed from there, it is necessary that the direction and velocity of the wind be measured from the roof of the building, about 300 ft. above. The roof mechanism which is shown, as constructed, in the accompanying sketch, is of simple design, consisting of a set of anemometer cups which are mounted on a trunnion with ball-bearing support at the top of a pipe standard, immediately below which is mounted a wind vane arrow that is balanced on a trunnion casting, that surrounds the pipe standard and is similarly carried on a ball-bearing. The latter trunnion is arranged over a number of electrical contacts that surround the supporting pipe standard and are touched in order by a traveling contact carried by the vane, as the latter is caused by the wind to point in different directions. The wires from the latter contacts are carried down to the office of the chief engineer in the sub-basement and so connected to a group of incandescent lamps arranged in a circle as to indicate there, by means of the lamp lighted, the direction of the prevailing wind outside of the building.

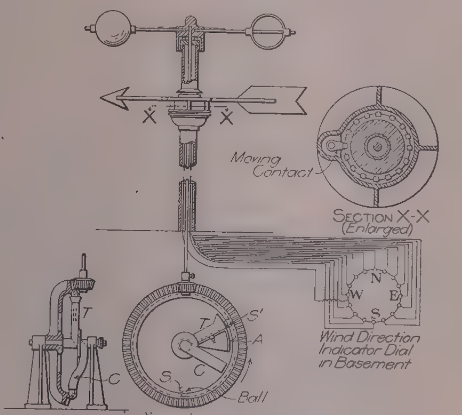
From the anemometer trunnion there is suspended within the pipe standard a slender shaft through which it drives by bevel gearing a wheel on a horizontal shaft that contains an electric contact mechanism for the purpose of signalling to the basement. The beveled gears are so proportioned that the large horizontal gear makes one revolution for every so many turns of the anemometer shaft and thus one electrical contact is made in this time, which establishes a definite relation between the number of contacts per minute and the number of revolutions of the anemometer trunnion. This contact is connected by wires leading to the basement, to either a small incandescent lamp or single stroke bell which will light or ring each time the large gear wheels turns and thus serves when the latter are timed, to indicate the number of turns of the anemometer and consequently the velocity of the wind.

The wind direction indications are made by means of a contact carried on the pointer side of the wind vane trunnion, which, as the vane turns, makes contact serially with 16 different stationary contacts around the circle; from the stationary contact wires lead separately to small incandescent lamps, which, as they light up indicate by their position the direction in which the vane points. For the latter purpose a special form of indicator was devised consisting of a large size plan of the hotel building that is placed on the wall of the engine room, with the various lights located on the different sides and corners of the plan; thus when the wind is from the north, a lamp lights up on the north side of the plan, when from the northeast, a lamp lights up at the northeast corner of the plan, and so on.

The constructional details of the mechanism have, as indicated in the accompanying sketch, been simply worked out, the wind direction indicator device consisting principally of the 16 stationary contacts carried on the pipe standard over which revolves the wind vane trunnion; the latter carries a moving contact placed on the side of the trunnion nearest the pointer and has been carefully designed to exclude the weather for protection of the wiring connections and contacts. The anemometer contact device was necessarily more complicated, as owing to the delicacy of this instrument, a sliding or rubbing electrical contact was undesirable owing to the damping effect which it would have upon the turning of the anemometer cups. For perfect freedom in turning of the latter, a metal-ball rolling-contact device has been used which gives good positive contact with a minimum of damping effect upon the anemometer. It consists simply of a ball runway in the large horizontal gear wheel driven by the anemometer pinion, which runway has a stop, S, that catches the ball on each revolution and elevates it to the upper part of the circle where it rolls off into the tube T, carrying the electrical contact. The latter contact consists of two insulated strips of metal of considerable length, placed side by side in the bottom of the tube, so that the metal ball in passing through must roll over them and form the contact. This tube is adjustable to different angular positions in the circle as may be found desirable, the apron A, preventing the ball dropping off of stop, S, and out of the runway before it reaches the position corresponding to S^1. After the ball has passed through the tube, it returns to the runway in the gear wheel again through chute C. The chute is also adjustable in position and may be so placed as to return the ball to the runway without missing a revolution in the case of the highest wind velocities. This apparatus was invented by Mr. J. G. Jurgenson and has been in use in the hotel over a year with perfectly satisfactory results and has proven of great assistance in the regulation of the heating service of the hotel.

Cost of Operating the Brooklyn Asphalt Repair Plant and of Laying the Pavement.

The Bureau of Highways of the Borough of Brooklyn, N. Y., erected a municipal asphalt plant last year in order to handle the repairs of those pavements on which the contractors' guarantees have expired. The plant has been in operation since June 13, 1907, and the results have been so satisfactory that plans for a second plant are now being prepared. At the present time the contractors' guarantees have expired on 1,738,000 sq. yd. of pavements; those on 935,592 additional yards will expire this year, and those on approximately the latter area in 1909.



Details of the Anemometer.

The asphalt plant, which was fully described in The Engineering Record of May 11, 1907, is housed in a steel-frame fireproof structure, containing two mixers, three driers, and three asphalt melters. The power equipment consists of a 50-h.-p. Erie engine, an 8-h.-p. Sturtevant engine, a 6 x 8 x 12-in. Knowles air compressor, and a 65-h.-p. water tube boiler. The driers are of the rotary cylindrical type; the melters, mechanically agitated. There is a weighing hopper above each mixer, and the trolley buckets for carrying the liquid asphalt have spring scales. Trolley tracks lead from the melters to each mixer, a barrel elevator is used for raising the cold asphalt to the second floor, while bucket elevators raise the sand, stone and dust to the storage bins on the third floor. The plant was built by the Warren Asphalt Paving Co.

The street plant, besides the necessary small tools, consists of twelve asphalt trucks and four 5-ton Iroquois steam rollers.

The asphalt repair work and the operation of the plant are under the Bureau of Highways, Borough of Brooklyn, Mr. John C. Sheridan, chief engineer.

The following data on the costs of operating the plant and laying the binder and the wearing coat are for the period from the beginning of operation on June 13, 1907, to Dec. 31, 1907:

Cost of Plant.

Contract	$22,485.00
Eng. and boiler found., piles, etc.	509.54
Office and sheds	712.00
Fire exting.	150.00
Oil tank	365.00
Extra parts, machinery	411.76
Office furniture and equipment	174.28
Electrical work (wiring, lights, annunciators)	58.80
Four asphalt rollers	6,156.00
Twelve asphalt trucks	4,920.00
Tools and gang equipment	2,000.45
Miscellaneous	337.35
Total	$38,280.18

Fixed Charges.

Interest on payments on above at 5 per cent.	$897.10
Depreciation on plant at 10 per cent., 6½ months, on $37,892.08	2,052.49
Rent of plant grounds, $1,440, 7 months	840.00
Total	$3,789.59

The total product of the plant was 8,475 boxes of wearing surface and binder. These boxes are 9 cu. ft. at the plant. During transportation from the plant to the job there is a consolidation of the wearing surface material in the truck. This has been found to be on an average load and distance a trifle less than 3 per cent. of the original bulk. On binder this consolidation is not appreciable. The 9-ft. box of wearing surface mixture as delivered on the job is therefore taken to contain 8.75 cu. ft. The total product of 8,475 boxes is divided into 6,951 boxes of wearing surface mixture and 1,524 boxes of binder. Allowing 8.75 cu. ft. of wearing surface to the box and 9 cu. ft. of binder gives a product of 60,821 cu. ft. of the former and 13,706 cu. ft. of the latter, a total of 74,537 cu. ft.

The expenditures for supervision, labor, materials and supplies on the above production was as follows:

Superintendent, asphalt repairs	$1,363.13
Plant labor (including foremen)	12,188,34
Street labor (including foremen)	19,970.33
Trucking, team and driver, at $6 per day	7,915.25
Cord wood (68 cords)	771.00
Dumping privilege	149.05
Oil	166.34
Waste	92.08
Rosendale cement	150.00
Canvas covers	35.45
Miscellaneous supplies	63.15
Coal for rollers, 47.6 tons, at $5.50 per ton	261.80
Coal for plant, 315 tons, at $3.98 per ton	1,253.70
Repairs, tools	206.23
Repairs, plant	769.95
Flux (96,820 lb.), 12,102.5 gal., at 7⅜ cts. per gal.	892.52
Asphalt, 40 tons, at $24.77 per ton, 295 tons at $24.80 per ton	8,306.80
Stone dust, 218.3 tons, at $3.50 per ton	764.00
Binder stone, 586.4 cu. yd., at $1.45 per cu. yd.	850.32
Asphalt sand, 2871 cu. yd., at 75 cts. per cu. yd.	2,078.25
(Less credit on 100 cu. yd., at 75 cts., of grit to Wallabout.)	
Total	$58,247.69
Fixed charges	3,789.59
Total	$62,037.28

The product was made up as follows:

For 6,951 Boxes of Wearing Surface:

* 2771 cu. yd. sand at 75 cts. per cu. yd.	$2,078.25
592,416 lb. dust at $3.50 per ton	764.00
91,274 lb. (11,409 gal.) flux at 7⅜ cts. per gal.	841.41
631,630 lb. asphalt at $24.80 per ton	7,832.21
Materials for 6,951 boxes, cost	$11,515.87
Cost per box	1.657

* Sand measured in scow (as paid for) allows for waste in yard, tailings and loss of weight on moisture. The actual quantity of heated dry sand as weighed in on mixing platform was 2,136 cu. yd. Weights of stone, asphalt, flux and dust as weighed in.

For 1,524 Boxes Binder:

586.4 cu. yd. stone at $1.45 cu. yd.	$850.32
5,546 lb. (693 gal.) flux at 7⅜ cts. per gal.	51.11
38,370 lb. asphalt at $24.80 per ton	475.79
Materials for 1,524 boxes, cost	$1,377.22
Cost per box	.904

All prices are for the materials delivered in the yard at the plant. The cost per box for supervision, fixed charges, supplies, coal and repairs was $1.070 per box, or $0.1222 per cubic foot for the wearing surface and $0.1190 per cubic foot for the binder. The cost per box for labor and trucking was $4.727 or $0.5400 per cubic foot for the wearing surface and $0.5252 per cubic foot for the binder.

Summary of Costs in Place.

	Wearing Surface.		Binder.	
	Per Box.	Per Cu. Ft.	Per Box.	Per Cu. Ft.
Materials	$1.657	$0.1894	$0.904	$0.1004
Supervis., Fixed Chg., Etc.	1.070	0.1223	1.070	0.1190
Labor and Trucking	4.727	0.5402	4.727	0.5252
	$7.454	$0.8519	$6.701	$0.7446

This cost for wearing surface is on a basis of 8.75 cu. ft. per box as delivered on street, equivalent to $0.85 per cu. ft. for wearing surface and for binder, 9-ft. box, $0.745 per cu. ft.

The wages paid for an 8-hr. day were: Plant foreman, $6; foreman, $4; rakers and tampers, $2.50; smoothers, laborers, $2; trucks, $6.

Detailed Costs:

General Costs, Delivered on Street.

	Wearing Surface and Binder Per Box.	Wearing Surface Per Cu. Ft.	Binder, Per Cu. Ft.
Superintendence	$0.1608	$0.0184	$0.0179
Plant Labor	1.4380	0.1645	0.1598
Street Labor	2.3560	0.2695	0.2618
Trucking	0.9338	0.1067	0.1037
Wood-Fire Wagon Fuel	0.0909	0.0103	0.0101
Coal—Plant	0.1478	0.0169	0.0164
Coal—Rollers	0.0307	0.0034	0.0034
Dump Privilege	0.0176	0.0020	0.0020
Rent	0.0990	0.0113	0.0110
Interest	0.1058	0.0120	0.0117
Depreciation	0.2420	0.0277	0.0269
Repairs to Tools	0.0243	0.0027	0.0027
Repairs to Plant	0.0906	0.0103	0.0102
Miscel. Supplies	0.0597	0.0068	0.0066
	$5.7970	$0.6625	$0.6442

Material Costs.

	Binder, Per Box.	Wearing Surface Per Box.	Wearing Surface Per Cu. Ft.	Binder, Per Cu. Ft.
Flux	$0.0340	$0.1210	$0.0139	$0.0037
Asphalt	0.3120	1.1270	0.1287	0.0347
Sand	......	0.2990	0.0342	......
Dust	......	0.1100	0.0126	......
Stone	0.5580	......	......	0.620
	$0.9040	$1.6570	$0.1894	$0.1004
Plus General Costs	5.7970	5.7970	0.6625	0.6442
Totals	$6.7010	$7.4540	$0.8519	$0.7446

The charge for trucking, $7,915.25, is total truck time at $6 per day, and includes all delays at plant and on street and also trucking of old asphalt and débris to dump. The average haul was 4.14 miles from plant, i. e., 129 loads traveled 534.4 miles from the plant to jobs in 25 different locations in all sections of the borough.

Observation on 35 loads for rate of travel for loaded trucks, 72 cu. ft. of wearing surface on load, gave 2.15 miles per hour.

Have had free dump on a considerable quantity of old asphalt.

The total number of working days was 134 out of 202.

The cost per box for labor (plant and street) has varied considerably, depending principally on the output.

Standard Gauge Substitution.

Standard gauge substitution for a 3-ft. 6-in. narrow gauge line was carried out last summer by the Imperial Railways of North China on one of the lines in Manchuria built by the Japanese during their war with Russia. The line is about 38 miles long, and terminates in Mukden. Although the line has but a single track, traffic consisting of two passenger trains each way per day was continued without interruption, a narrow gauge train being started from one end and a standard gauge train from the other end at such times as would allow them to meet about the same hour on either side of the track-laying gangs. The work was carried on so as to allow the two trains to come within ½ to ¾ of a mile of each other. The operation of changing to the broader gauge was carried out in three distinct operations. The first of these consisted in drawing the spikes in alternate ties, and since the maximum speed of trains was under 20 miles an hour, this did not make any change in operation. Lines 7¼ in. outside the base of the rails were then marked on the ties to indicate the new position of the steel. The second operation consisted in the actual change of gauge and was carried out by three distinct gangs. The first gang drew out all of the outside spikes, leaving the inside ones undisturbed. The second gang spiked one of the rails and the third gang spiked the other rail to the same ties, only alternate ties being spiked. This second operation took a trifle over eight days. The third and last operation consisted in removing the inside spikes and then completing the spiking of the standard gauge tracks. In order to expedite the work, the Chinese track layers were paid about double ordinary rates, and worked from 4.30 in the morning to 7.30 at night, with an intermission of an hour at noon, though a lunch was served at 8.30 in the morning and again at 4.30 in the afternoon without, however, taking out time.

Erecting a Power House with a Long Derrick Boom.

The recent extension of the Lincoln Wharf Power Station for the Boston Elevated Ry. Co., Boston, involved the erection of about 900 tons of steel columns, beams, girders and trusses, forming four regular transverse bents and three special bents of the boiler and engine room, described in The Engineering Record of Aug. 17, 1901. The work was so rapidly performed as to earn a bonus offered for its completion thirty days ahead of contract time, and the method of erecting the boiler room and coal bunkers with a single-guy derrick, supplemented by jinnywink derricks on the roof, was illustrated in The Engineering Record of Nov. 2, 1907.

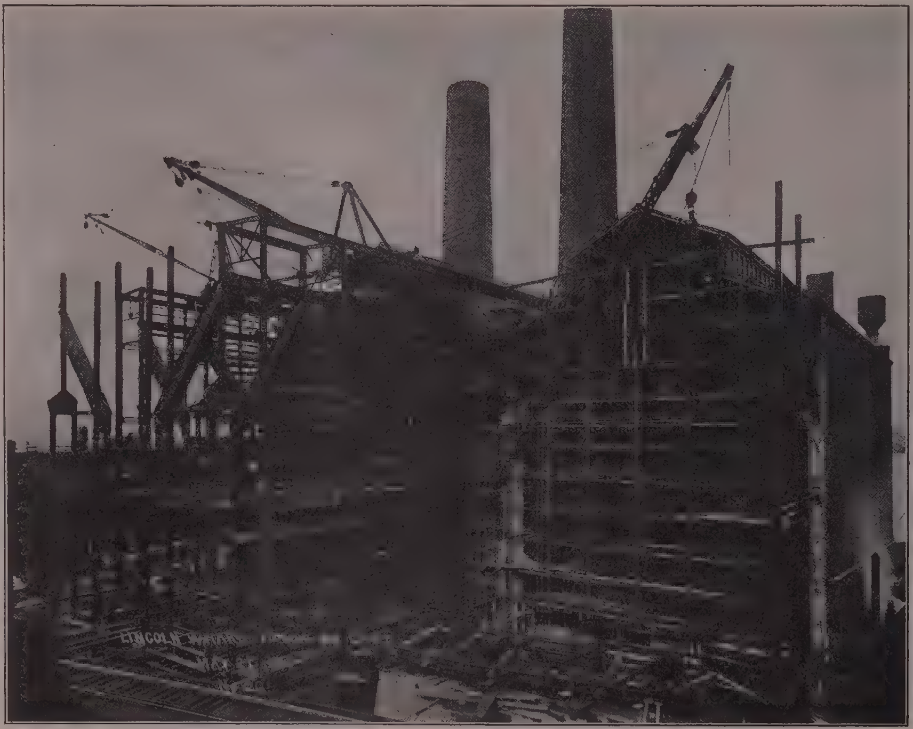
A large proportion of the steel in the concrete is in the boiler house, and after its erection the comparatively small amount of steel in the engine house was erected in the simplest possible manner with great rapidity and convenience. The additional framework required for this portion of the building consisted substantially of the columns and bracing for the end wall and one side wall, one line of runway girders for the traveling crane and the roof trusses and bracing and purlins, which enclose an unobstructed space about 68 ft. wide and 92 ft. high. The 80-ft. steel boom from the derrick used on the boiler room was connected to one of the boiler room partition wall columns near the middle of the building in a position commanding the whole area and enabling it to erect all of the remaining steel work without being moved.

This boom was of the standard extension type for heavy work used by the contractors and forming part of their regular plant. It is made with two tapered end sections, each 30 ft. long, which can be used together or with one or two 20-ft. intermediate sections, both of which were inserted for this work.

All of the sections have a rectangular cross-section made with four 3 x 3-in. angles, with their flanges turned inward, latticed, connected at the extremities by cover plates and stiffened by transverse diaphragms about 10 ft. apart, which are considered very important features of the design. The intermediate sections are made with straight angles and have a uniform width and breadth of 24 in. from end to end. The lower end of the boom is bored for a horizontal pivot pin connecting it to a cast-iron knuckle block, with a vertical pivot bearing in a steel end timber foot block.

The horizontal 12 x 12-in. timbers to which the steel portion of the foot block was thoroughly bolted were seated on floor beams in the boiler room, about 15 ft. above the level of the engine house basement floor, and were securely anchored to them so as to project a few feet into the engine room and form a cantilever support, carrying the boom far enough beyond the face of the wall to give it good clearance and a complete swing of 180 deg. These beams were set close to the foot of one of the intermediate partition wall columns which serve as a mast for the boom and was provided at the top of the boiler room roof with connections for the hoisting and topping lift tackles.

The boom thus located and rigged was operated by an American Hoist & Derrick Co. hoisting engine, located on the ground on the opposite side of the boiler room, and erecting the columns, bracing and crane girders in the two remaining walls of the engine house, handling pieces of a maximum weight of about six tons.



Extended Steel Boom Erecting Eaves Struts.

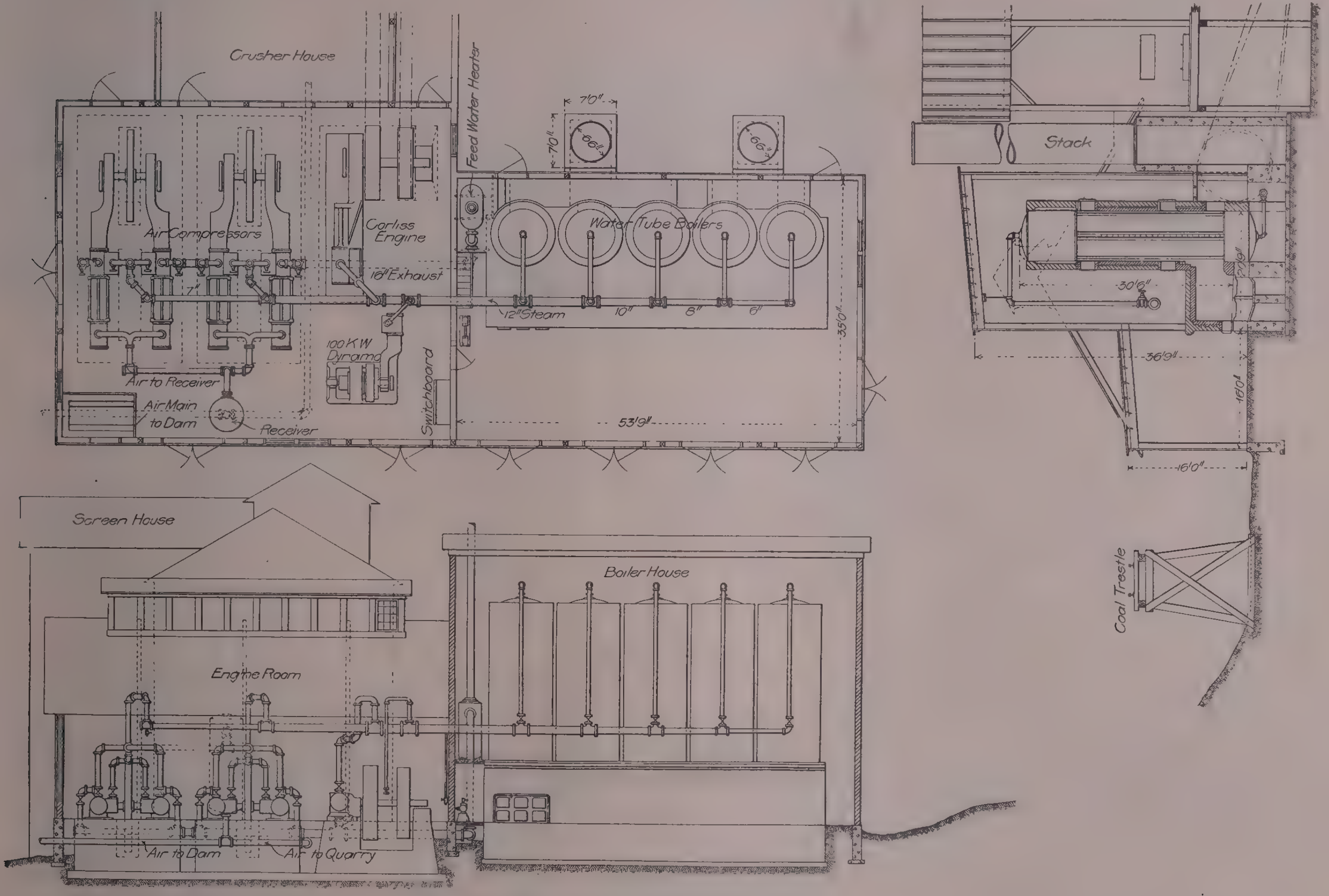
The boom while reaching the full width and height of the room was not long enough to command its diagonal as was necessary to set the eave struts on top of the column in the opposite wall from its foot. As these were fortunately very light, it was permissible to increase the length of the boom to handle them, and this was effected by adding to its extremity an 8 x 8-in. timber thoroughly lashed with Manila rope and projecting about 15 ft. beyond the point of the boom. This piece was arranged so as not to interfere with the main tackles and their connections, and was provided with a snatch block, to which a Manila runner line was rove, and led back to the capston head of the hoisting engine. This device enabled the most inaccessible members to be easily erected, after which it was removed, and the roof trusses and purlins were erected, with the 100-ft. steel boom used in the ordinary way. L. F. Shoemaker & Co. were the contractors, and the erection was directed by Mr. L. D. Rights.

American Coal for gas making is being tried in France by the Marseilles Gas Co. The coal came from West Virginia, and is said to have cost 22 s. in Marseilles.

Some Construction Methods at the Croton Falls Reservoir.

The diverting dam across the east branch of the Croton River is designed to deflect the flow of the stream to the main reservoir on the west branch of the river through a canal or connecting channel about 3,700 ft. long, as described in The Engineering Record of Jan. 18. It intersects the river approximately at right angles near the center of a bend where the channel is about 100 ft. wide and is built of rolled earth with a core wall of cyclopean masonry.

It is 1,185 ft. long on top with a maximum height of 50 ft., a width of 15 ft. on top and a maximum bottom width of about 245 ft., a large dimension due to an offset on the down-stream slope to carry the highway. The core wall is 5 ft. thick on top and extends from end to end of the dam with its footings carried down to a maximum depth of 85 ft. below the crest of the dam in a trench excavated everywhere to sound rock, sometimes 4 ft. below the original surface of the rock and 43 ft. below the original surface of the soil.



Main Power Plant at Croton Falls Reservoir.

During the construction of the dam the river was diverted from its site by a temporary earth dam about 700 ft. long and 18 ft. high built across the valley about 900 ft. upstream from the permanent dam, at a point where the river channel is about 100 ft. wide and 6 ft. deep. The dam is about perpendicular to the axis of the valley and slightly oblique to the axis of the river channel, intersecting the latter at the extreme east side of the valley. The axis of the dam is a tangent from the west end to a point just east from the river channel at the intersection with the flume, east of which it curves upstream for a short distance to the end.

The water diverted by the temporary dam passes through the wooden flume about 850 ft. long to the permanent waste channel serving the diverting dam and discharging into the original bed of the river about 1,000 ft. down stream. The top of the temporary dam, about 30 ft. wide, is at elevation 297 and both up and downstream faces have slopes of 1½ to 1, protected by an overfall 60 ft. long at elevation 294.

The overfall section is made with crib work of round timber and is 10 ft. wide on top and has both upstream and downstream faces sloped about 1:1. The top and upstream surfaces are covered with plank and connections are provided on the center line for flash boards about 1 ft. high. The crib is seated on a timber apron about 25 ft. wide, made with 6-in. transverse planks spiked to longitudinal sills bedded in the surface of the soil, and is protected by sheet pile cut-off walls about 16 ft. deep driven across the upper and lower edges. The upstream face is farther protected by riprap sloped about 2:1.

During the construction of this dam the low water flow of the river was carried through it in a 3 x 3 ft. rectangular wooden conduit provided with a double set of stop planks at the upper end and constructed with splined 3-in. spruce planks laid longitudinally in the bottom and sides and transversely on the top, and spiked to 6 x 8-in. transverse sills and vertical posts about 5 ft. apart.

The main flume, 940 ft. long, is on a tangent except for a short distance at the lower end where it curves downstream slightly. It is 24 ft. wide and 8 ft. 2 in. deep inside, and is built with a total slope of 1½ ft., intended to provide for a maximum flow of 50,000,000 gal. of water daily; so far it has only run about one-third full. Its construction corresponds with that of the flume for the main dam which was described in our issue of Jan. 18.

The intake is about 5 ft. above the original surface of the ground and is supported on a fill retained at the upper end by a cut-off wall of wooden sheet piles driven across the floor of the flume which is carried about 7 ft. upstream beyond the ends of the sides. The face of the sheet piles above the surface of the ground is protected by riprap sloped about 3:1 and the sides of the channel adjacent to the intake and of the adjacent upstream slope of the dam, are also protected with riprap. The dam contains about 140,000 cu. yd. of fill which was provided by the excavation for the adjacent permanent dam.

A through preliminary exploration of the site of the diverting dam, waste channel and connecting channel was made by about 35 test pits, 25 wash borings, which for the dam indicated that rock had an average depth of about 30 ft. over most of the length overlaid with sand, gravel and boulders arranged in irregular strata. In the waste channel the bed rock was nearer the surface and in some places outcropped, and in the connecting channel it appeared to vary from about 8 to 12 ft. below the surface, being in all cases covered with sand, gravel and boulders. So far these indications have been substantially verified by the materials encountered in excavation as the work progresses.

Excavation for the diverting dam was commenced with two steam shovels and the entire 4,000 cu. yd. of earth have been removed. About one-half of the rock excavation for the core trench has been completed, part of the core wall has been built and work on the earth fill embankment has been commenced.

The connecting channel is 30 ft. wide on the bottom with walls sloped ¼:1 in rock and its construction involved 200,000 cu. yd. of earth and 110,000 cu. yd. of rock excavation, besides considerable rubble masonry in the retaining walls and the heavy paving. Work on it is in progress with two steam shovels and 20 rock drills and an average force of about 85 men. The excavation is now about one-third completed and the paving is in progress with five boom derricks installed to handle the large stones with which this massive protection, 3 ft. thick, is laid. The rock in this excavation is drilled as in the quarry with well-drilling machines, which make a hole 6 in. in diameter to the full depth of the excavation. The holes are sprung once or twice and fired with dynamite, displacing and shattering the rock so that most of it can be handled with the steam shovel.

Power for the operation of all the plants required for the construction of the main dam will be developed at a steam plant located about 2,400 ft. north of the dam and 1,200 ft. south of the principal quarry at elevation 325 on the east side of the valley. Immediately adjacent to it is located the crushing plant and the sand and stone storage and elevating plant, all of which have been designed with great care to give the most rapid, efficient and economical service and to provide a capacity sufficient for the utmost demands of the work. A considerable proportion of the installation has been completed and it is expected that the entire plant will be in operation as soon as or before the other conditions permit the commencement of laying concrete masonry.

The power house is a wooden building about 100 ft. long and 50 ft. wide and 40 ft. high to the top of the boiler house roof. It has concrete footings for the walls and massive concrete foundations carried down about 5½ ft. below the surface of the soil to rock for the boilers and machinery. There is a battery of five 333-h.p. Wickes Brothers vertical water tube boilers equipped with a Wickes Brothers feed water heater and an open type feed pump and connected to two 66-in. steel smoke stacks 25 ft. high on concrete pedestal 20 ft. high.

The steam main, commencing with a diameter of 6 in. at the first boiler increases to 12 in., and after supplying the Westinghouse 100-kw. dynamo decreases to 10 in., and to 7 in. between its connections with the 300-h.p. Corliss engine which drives the stone crushers and elevator plant and the two Vulcan air compressors, each of them having a capacity of 2,000 cu. ft. of free air per minute. The compressors are connected to a receiver 60 in. in diameter and 25 ft. high, from which 6-in. mains lead both to the quarry and to the main dam, supplying air at a pressure of 125 lb. for all pumps, drills, hoisting engines and most other machinery except the locomotives and steam shovels.

Adjacent to the power house is the 32 x 64-ft. crusher house 54 ft. high with a pit 8 ft. deep in which are massive concrete foundations for three McCully stone crushers with their receiving platforms about 13 ft. above the surface of the ground. Stone is delivered from the quarry to the crusher platform in dump cars drawn up the inclined trestle by a locomotive. They discharge their contents directly into the hopper of the No. 10 crusher which receives stones up to 26 in. in the smallest dimension and has a rated capacity of 450 cu. yd. per hour.

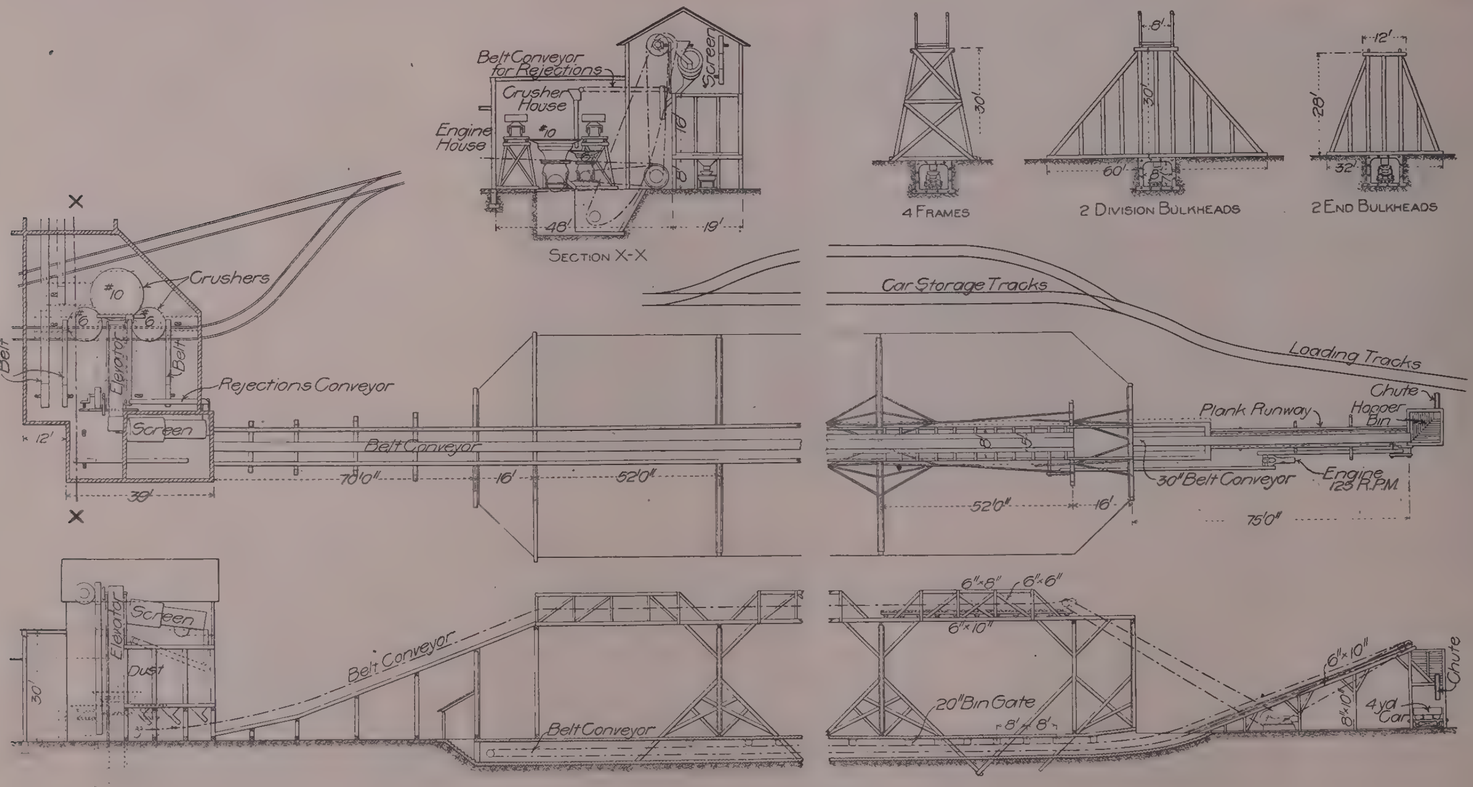
The 4-in. stone from this crusher is elevated about 54 ft. by a slightly inclined No. 9 Power & Mining Machine Co. conveyor with steel buckets of about 2 cu. ft. capacity each, and discharged directly into a standard inclined cylindrical screen of the same make, which is 6 ft. in diameter and 28 ft. long. The screen has holes ¼ in., 2 in. and 3 in. in diameter and discharges the dust and 2-in. and 3-in. stone into different bins, returning the rejects which fail to pass any of the holes to the two No. 6 McCully crushers, each with a capacity of 50 cu. yd. per hour, which reduce the stone either to 1 in. or 2 in. sizes as required and deliver to a second conveyor of the same make as the first which elevates it to separate bins with a combined capacity of 300 cu. yd.

The bins have hopper bottoms controlled by gates which deliver through inclined chutes to a 30-in conveyor 365 ft. long, of the Robins type, installed by the contractors. The belt ascends at an angle of about 30 deg. to an elevation of about 32 ft. above the surface of the ground and is carried at that level along the full length of a bridge about 260 ft. long. The bridge is made with five 52-ft. wooden Pratt truss spans supported on single trestle bents knee-braced top and bottom longitudinally.

On the center line of the bridge there is a full-length rectangular tunnel 8 ft. wide and 7 ft. deep inside with 12-in. concrete walls and a roof slab flush with the surface of the ground. On the center line of the tunnel roof 20-in. bin gates are set at intervals of 8 and 9 ft., with hand levers operated from the interior of the tunnel.

The space above the tunnel underneath the bridge is intended for the storage of piles of sand and stone on the surface of the ground which will be dumped at any time and place by a movable tripper traveling from end to end of the bridge. The materials will thus form a triangular bank or pile 60 ft. wide at the base, and 30 ft. high, with the sides sloped at the natural angle, and providing a total storage capacity of about 15,000 cu. yd. The space will be divided into three separate bins by transverse bulkheads each 78 ft. from the center line of the bridge. At these points the

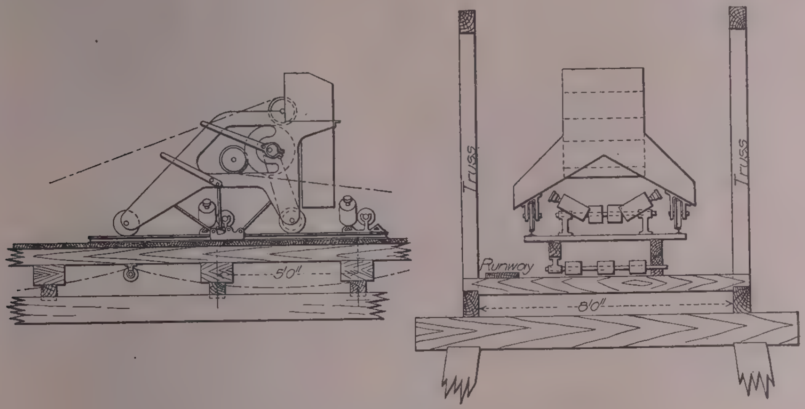
Loading Bins and Trestle for Sand and Stone.



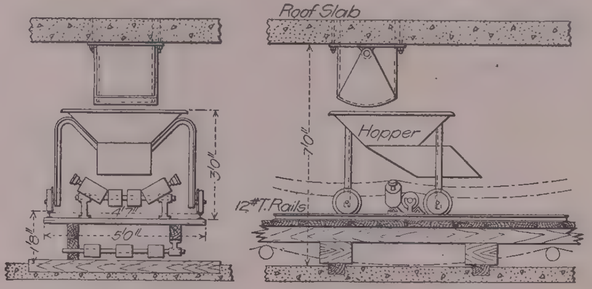
Stone Crushing, Storing and Loading Plant.

bridges are supported on special transverse trestle bents made with nine vertical 12-in. posts sheeted on both sides to a height of 14 ft. with horizontal 3-in. planks and above that sheeted with 2-in. planks. These are strongly braced longitudinally to resist at the center an unbalanced pressure of 256 lb. per square foot and at the base a pressure of 460 lb. per square foot when one bin is empty and the adjacent bin is full. When the bin is full the load on the tunnel roof is 33,000 lb. per lineal foot.

A second 30-in. conveyor belt 365 ft. long on centers is operated by a belt driven by pulleys at the outer end of the upper conveyor belt. The lower belt extends through the full length of the tunnel and emerging at the outer end ascends with a vertical curve and a tangent at an inclination of about 30 deg. with the horizontal, supported on a timber trestle, to a height of about 24 ft., where the belt, reversing, discharges its burden into a hopper bottom bin of 20 cu. yd. capacity, divided by a partition into two equal chambers for the storage of sand or broken stone which can deflect into either at pleasure by means of a swinging flap at the top. A 3-ft. gauge track passes underneath the bin with sufficient clearance for 4-yd. side-dump cars to pass under and be filled with sand or broken stone delivered through a gate in a chute at the bottom of the bin.



Conveyor and Tripper.



Loading Belt and Traveling Hopper.

Sand will be excavated by a steam shovel from pits in the bottom of the valley within a mile of the storage bins and will be hauled in dump cars to the elevator at the crusher house which will either deliver it directly to the storage bin, or, if it is necessary to screen it, will deliver it to the same screen through which the stone is passed, after which it will proceed to the storage bin. Obviously the elevators and conveyor belt must be used alternately for broken stone and sand, but their capacity and that of the stone crushers is such that they will only need to run a portion of the time on each to supply all the materials needed for more than 1,000 cu. yd. of concrete in 10 hours.

The tripper which dumps the burden of the upper belt into the storage bin is of special construction, as indicated by the accompanying details, and is provided with A-shape chutes deflecting the materials equally in opposite directions to both sides of the bins. The chutes in the tunnel roof are simple vertical cast-iron frames with the bottoms closed by a pivoted cylindrical segment which is easily operated by hand and eliminates much of the friction and resistance. The chutes discharge, not directly to the belt, but to a steel hopper mounted on a light rolling steel tower carried on rails each side of the conveyor belt. The bottom of the hopper terminates in a chute parallel with the belt which delivers the sand or stone close to the surface of the belt nearly tangent to it and in the direction which the belt travels. This arrangement is intended to insure an accurate and regular distribution of material on the belt and to prevent scattering.

From the loading tower at the end of the tunnel belt the sand and stone is conveyed to either of three Hains mixers, each with a capacity of 400 cu. yd. in 10 hours. The mixers are about 6 ft. in diameter and 5 ft. high and the material cars are pulled by locomotives on inclined trestles to the tops of the mixers and discharge directly into their hoppers. One mixer about 400 ft. west of the storage bins is intended for concrete used in the cast blocks and will deliver the concrete directly into the moulds, five or six of which will be placed on each of a large number of flat cars and moved up to the mixer and will thence be transferred direct to the storage yard where the moulds will be stripped and the blocks removed as soon as they are old enough to be handled, thus releasing the cars for repeated service.

The other two mixers are located on each side of the axis of the dam at the east end and are both commanded by a single boom derrick which delivers the material to the charging hopper, and removing the 2-yd. buckets of concrete, delivers them to the two cableways which command the entire length of the dam. It is estimated that this plant has a capacity for mixing about 800 yd. of concrete in 10 hours, and that under favorable conditions about 1,000 cu. yd. can be laid in the dam and about 100 yd. cast in blocks in each day. It is thus seen that great pains and a large outlay have been devoted to the greatest possible elimination of hand labor and the establishment of an improved power plant and operating machinery intended to promote the rapid execution of a very large quantity of work and that the economy in operating expenses is expected to justify the large sum invested in the equipment.

In order to provide abundance of potable water for the dams and a satisfactory supply for mechanical purposes without the work and expense of pumping from the Croton River, the contractors have built an earth dam about 150 ft. long and 20 ft. high and have established an impounding reservoir at elevation 490, about 10,000 ft. from the site of the dam, and have thus secured a maximum storage of about 10,000,000 gal. with a head of about 175 ft. above the highest part of the work and have connected it with the dam and power house with a 6-in. main.

A 50 x 100-ft. wooden building has been constructed near the east end of the main dam and is equipped with air-driven standard machine tools and hand tools necessary for ordinary machine shop and repair shop work and the construction of simple plant. There are also several buildings for general storage, smith shop, carpenter shop, tool house, engine house, etc., and a large dwelling near the diverting dam which is used for general headquarters and contractor's offices. There is at this place also a stable with stalls for 100 horses and a special shop for the manufacture and repair of harness, another for horseshoeing and a third for wagon making.

There is, including the plant already specifically enumerated, a general equipment of about 2,000 total h.p., including the auxiliary boilers and exclusive of the steam shovels and locomotives. There are 12 locomotives, about 1,400 tons of steel rails, two 3-yd. Bucyrus steam shovels, two 1½-yd. Marion steam shovels, six Wickes vertical steam boilers, two Vulcan air compressors, three McCully stone crushers, one Corliss engine, one Westinghouse dynamo, two elevators, one cylindrical screen, two belt conveyors, rock drills, Cameron, Worthington and centrifugal pumps, four Cyclone and Keystone well drills and about 20 hoisting engines of the Lidgerwood, Mundy, American Hoist & Derrick Co., and Rawson and Morrison makes, about 60 standard flat cars, most of them for use in the casting yard, and 100 4-yd. side-dump cars of the Allison, Weston and Continental types. Two 1,400-ft. span, 15-ton Lidgerwood traveling cableways, three concrete mixers and a large amount of miscellaneous plant and equipment involving, to date, an aggregate expenditure of about $410,000 for its purchase and installation.

The present force consists of about 1,000 Italians, Austrians, Negroes and other nationalities, including a few native Americans, most of whom are quartered in four camps established by the contractors in different localities near the main dam and the diverting dam. Each camp is so located that its drainage is efficiently cut off from the watershed of the reservoirs and has a store, commissary, eating house and numerous one-story bunk houses, each with a capacity of 15 to 20 men. Great care has been taken to avoid the possibility of contamination of the water shed and all garbage, both liquid and solid, is removed and incinerated daily. Sanitary conveniences are provided and are constructed on the septic tank principle, producing a clear effluent disposed of by irrigation and sand filtration, and closets are also provided for temporary purposes. Regular medical attendance and hospital care, when necessary, are provided for by the contractors and the camps are inspected by two engineers and daily by a sanitary patrol. So far there have been no epidemics, little sickness and very few accidents.

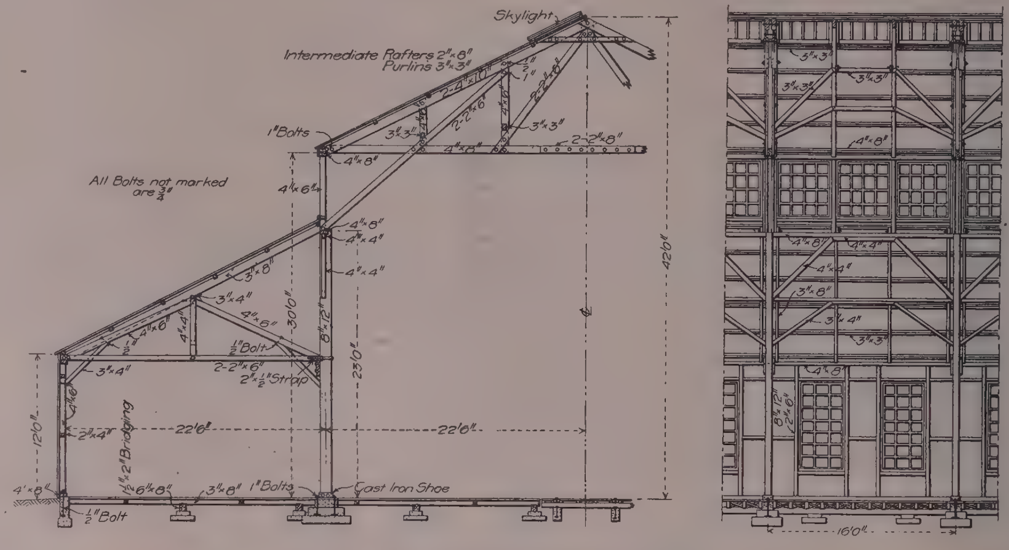
On the 1st of January, 1908, the condition of the work was substantially as follows: Estimated value of plant installed, $410,000; amount of estimates paid to date, $750,000; earth excavations for main dams, completed; rock excavation for main dam, about one-fourth completed; temporary diversion work, completed; excavation for permanent diverting dam, completed; rock excavation for core wall of diverting dam, one-half completed; embankment of diverting dam, about one-fifth completed; excavation of connecting channels, about one-half completed; retaining walls for connecting channels, about one-half completed; waste way for main dam, about one-half completed; highways, about one-third completed; boundary wall, about one-third completed; clearing reservoir site, about one-sixth completed;

nearly all track laid, excepting spurs to main dam, aggregating about 14 miles, boilers, stone crushers, storage, and elevating plants installed, derricks in service, cars and locomotives in operation, cableways and air compressors delivered at site and being installed. It is thus evident that although the work now completed is not up to the specification schedule in some respects, it exceeds it in others and the preparations and equipment are so efficient that the contractors believe that with the commencement of masonry laying in mild weather the work can be pushed at such a speed that it will be completed by contract time.

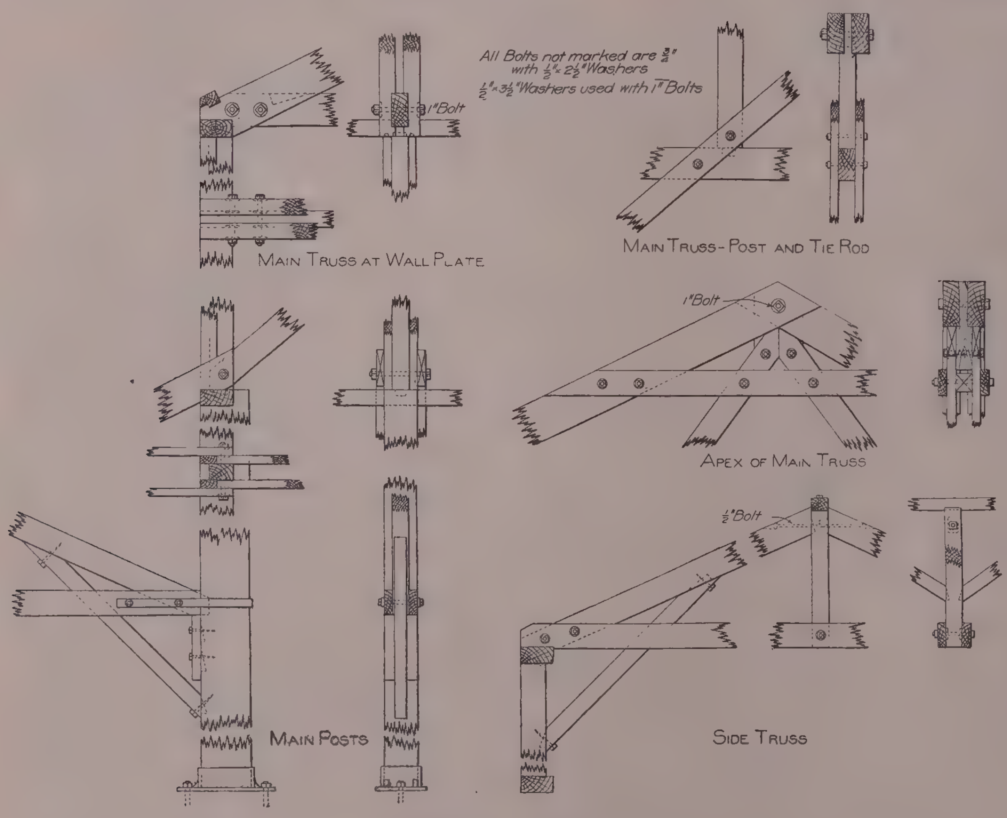
The plans have been made and the work is being executed under the direction of Mr. Walter H. Sears, chief engineer; Mr. Wm. H. Burr, expert engineer; Mr. Geo. A. Taber, assistant engineer; Mr. F. S. Cook, division engineer, and Mr. C. E. Smith, engineer in charge of main dam; Mr. H. Houck, assistant engineer in charge of diverting dam, and Mr. C. E. Benedict, assistant engineer in charge of highways. The contract was awarded August 23, 1906, at a total price of $3,028,000 for the estimated quantities, to the Croton Falls Construction Co., Mr. J. F. Cogan, president; Mr. P. J. Cogan, secretary and treasurer; Mr. P. H. Cogan, superintendent, and Mr. I. J. Forchner, manager.

A Large Wooden Frame Shop.

The 90 x 300-ft. shop for the Continental Car & Equipment Co., at Louisville, Ky., has a wooden framework with corrugated iron roof and wall sheathing and is of very light and stiff construction with wide unobstructed floor spaces. The columns are spaced 16 ft. apart in four longitudinal rows making one 45-ft. center aisle and two 22½-ft. side aisles. The building has a maximum height of 42 ft., to the peak of the main roof, and about 12 ft. to the eaves, and, being exposed to strong winds, is designed to resist a horizontal pressure of 25 lb. per square foot and has special transverse bracing to stiffen it for such stresses and distribute them through the different columns which are securely anchored to their concrete piers.



Half Section and Elevation of Building.


All Bolts not marked are 3/4" with 1/2"x 2 1/2"Washers
1/2"x 3 1/2"Washers used with 1" Bolts
1"Bolt
Main Truss at Wall Plate
Main Truss - Post and Tie Rod
1"Bolt
Apex of Main Truss
1/2"Bolt
Main Posts
Side Truss

Details of Framing.

The end diagonals of the main roof trusses are continued beyond the lower chords to intersect with the main columns and form knee braces approximately in line with the rafters of the side aisle roof, thus bracing the columns against lateral forces. The ends of the lower chords are seated on short vertical posts, connected to the feet of the knee braces and to the side aisle rafters and seated on 4 x 8-in. longitudinal plates mortised flush with the tops of the columns. The side rafters are supported at their extremities on the wall and center columns and in the center at the apexes of light triangular side aisle king post roof trusses, with both ends knee-braced to the columns. By this arrangement the side rafters brace the center columns and relieve their upper ends of bending moment and the upper and lower roof trusses are so combined as to develop a great deal of rigidity under transverse stress. Intermediate rafters about 5 ft. 4 in. apart, are seated on the 4 x 8-in. longitudinal wall plates connecting the columns which at these points are supported by wooden arch bracing, composed in the outer wall of 3 x 4-in. segments and in the plane of the clere-story of 4 x 4-in. segments. The center aisle rafters are supported at two intermediate points on each side by 3 x 3-in. knee braces to the feet of the vertical members of the main roof trusses. All connections are bolted and the principal diagonal web members of the trusses are made in pairs, one on each side of the chords and vertical pieces thus serving as scabs to join the others together. All timber in the trusses is made with convenient lengths of standard sizes and small dimensions and the amount of timber required for the structure compares very favorably with that necessary for ordinary construction. Mortise and tennon joints were provided for the principal members and the connections were designed so that the framing was simple and easy to fit. The bases of all columns were bolted to flanged cast-iron shoes ¾ in. thick with grouted bearings on the offset concrete piers. In part of the building there is an earth floor and in the remainder there is a floor of 1½ in. longitudinal maple plank laid on 3 x 8-in. transverse joists 16 in. apart carried on 6 x 8-in. longitudinal sills on concrete piers. A 3-ft. track on the longitudinal axis of the building has 4 x 8-in. ties 3 ft. apart spiked to two lines of 4 x 8-in. nailing pieces bolted every 8 ft. to 8 x 12-in. concrete longitudinals.

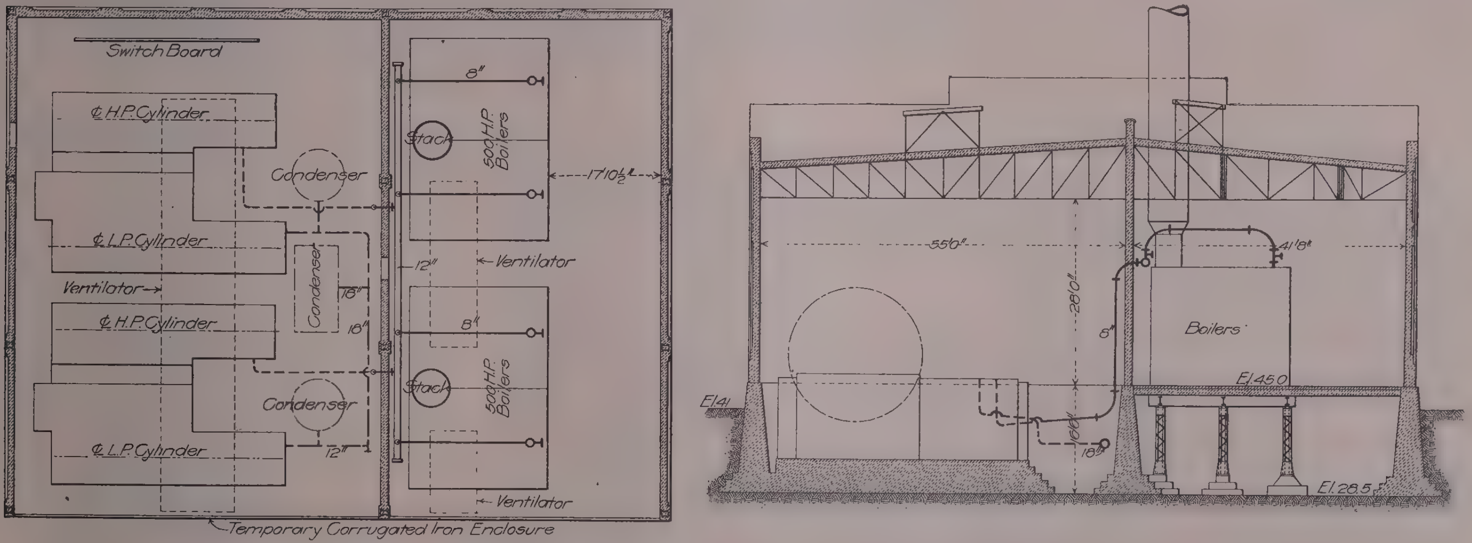
The center and wall columns, roof trusses and rafters were framed and assembled complete on the ground in each side aisle and were erected simultaneously on opposite sides of the building by a pair of traveling stiff-leg derricks which moved from end to end, revolved them into vertical planes and maintained them until braced and self-supporting. The main roof trusses with their knee braces and clere-story vertical posts were likewise assembled in two pieces each on the ground and were erected by a pair of gin poles moving from end to end of the building and holding them in position until the top and bottom chord splices were bolted and they were secured by the purlins and longitudinal braces. The building has been completed over a year and has proved satisfactorily rigid and strong under heavy winds to which it has been exposed. Foster, Gade & Graham, New York, are the architects.

Simple Concrete Forms were used recently in the construction of I-beam bridges across streets on the Memphis & State Line Railroad, a cut-off of the Illinois Central Railroad, around Memphis, Tenn. The I-beams are 18-in. 70-lb., spaced approximately 1 ft. 6 in. on centers and are incased in concrete, which is filled between the beams and 2 in. above the top flange. A light wire was passed over alternate beams and under 3-in. waling pieces which carried a 2-in. tight floor bearing against the bottom flanges of the beams. The forms were removed by cutting the wires from below.

Exterior of the Power House.

New Generating Station of the Merchants' Power Co., Memphis, Tenn.

A 1500-kw steam generating plant was recently placed in service by the Merchants' Power Co., a company organized in Memphis, Tenn., in 1906 for city street and commercial lighting service. The plant started out with two 75-kw. generating units for the initial load, but foreseeing large possibilities for the development of the station load, the plant was designed and laid out with ample provisions for extension of capacity. An advantageous location was secured for the plant adjoining the Wolfe River for water circulation, permitting the use of condensers and yet comparatively near the center of distribution of current supply in the city.



The New Power Plant of the Merchants' Power Co., Memphis, Tenn.

The site secured for the plant is a plot 400-ft. square at the corner of Keel St., and the Illinois Central R. R. and directly on the bank of the Wolfe River. As the Wolfe River is a tributary of the Mississippi River and subject to the high water resulting from the spring floods, the machinery is carried on high foundations of concrete which throw all apparatus well above the extreme high water level on record. The basement was excavated to a level 28½ ft. above low water level in the river while the generator foundations are carried up to a point 18 ft. above this. Both the boiler and engine room floors of the plant are on the 45-ft. level, bringing them 4 ft. above the highest water mark that has ever been recorded at that point. The soil underlying the site was of clay of good quality and the foundations are all carried on spread footings without piling. The building foundation footings which are separate from those carrying the machinery are spread for bearing pressures of 1000 lb. per square foot. The engine and generator units are supported on massive foundations of monolithic concrete, each of which rests separately on a large mattress of concrete spreading over an area of approximately 30 x 40 ft. in extent. The boilers are supported in batteries on two steel platforms formed of I-beams that are carried on lattice posts resting on separate foundation blocks.

The power house is a 75 x 100-ft. steel frame and brick structure which is divided into a 57-ft. engine room on one side and a 43-ft. boiler room on the other side. The building is, as will be noted from the accompanying plan, only an initial portion of a much larger plant to which it may be extended when required, the arrangement of all apparatus and the temporary wall at the west or river end of the structure, permitting an extension of the plant to double or triple its present size in that direction. Both the boiler and engine rooms have a basement with a clear head-room of 15 ft., and roof construction is carried on steel trusses spaced approximately 25 ft. between centers, and giving a clear head-room of both divisions of 29 ft. The floors are constructed of concrete. In both the boiler and engine room roofs there are monitors for lighting and ventilation, that over the engine room being a continuous monitor extending nearly the full length of the building, while the boiler room monitors are installed in detached sections over the spaces between batteries.

The boiler plant consists of four water-tube boilers supplied by the Edgemoor Iron Co., Edgemoor, Del., which have been set in the boiler room in two batteries, facing a 17-ft. firing floor on the outer side, with a 3-ft. space at the rear and 7-ft. spaces between settings. The boilers are of the Edgemoor inclined tube forged header construction, with two longitudinal steam drums and each unit has a total heating surface of 5090 sq. ft. The settings are fitted with plain grates for hand firing, bituminous coal being used, costing $2.00 per ton delivered at the plant, and the tube surface is divided by baffles for three vertical passes of the products of combustion. The latter are removed from the boilers by a 6-ft. steel stack, 115 ft. in height, one of which is installed over each battery. No mechanical equipment is as yet installed for the handling of coal and ashes, although the steel work of the building has been installed of ample strength to support overhead coal bunkers and a coal conveyor system if it shall prove at any future time desirable to install such equipment. Coal is at present delivered to the plant in cars on a siding from the Illinois Central R. R., and stored in piles outside of the boiler room from which it is wheeled to the firing floor.

The boilers are fed by either injectors or feed pumps, each boiler unit being equipped with a Metropolitan injector, which draws direct from a cold water suction line and delivers direct to the boiler. The feed pumps are 6 x 12 and 8 x 12 in. Smith-Vaile duplex pumps, which deliver through a Cochrane open feed water heater and feed delivery main which connects with all of the boiler units. The feed water supply is either taken from the Wolfe River or the city water main, the river water being used for feeding except when too dirty, as during freshets.

The steam piping is of a simple arrangement, consisting of a 12-in. header in the boiler room adjoining the division wall for the high-pressure system which has 8-in. branch connections to each of the boiler units and an 8-in. supply connection to each of the engines. The header is located above the level of the tops of the boiler settings, the boiler branches being run with long radius bends while the engine supply branches drop through on the engine-room side of the division wall into the basement for underfloor connections to the engine cylinders. There is also an exhaust steam system installed, consisting of an 18-in. header in the engine-room basement to which the low pressure cylinders of the engines are connected by 18-in. branches, these latter engine exhausts having each a local branch connection to its condenser unit. The exhaust header is connected at its mid-point to a large condenser unit which is installed in the basement between the two engine units to provide for operation of both engines with a single condenser if desired. This exhaust header has a full-sized atmospheric connection which is carried up through a back pressure valve to a roof exhaust head for relief from possible excess pressure.

The engine units that were selected for the station are horizontal cross-compound Corliss engines which were designed for a rating of 1,000 h.-p. when operating condensing with an admission presure of 125 lb. They are Reynolds Corliss engines built by the Allis-Chalmers Co., and have 23 x 46 x 48-in. cylinders, being designed to operate at 94 r.p.m. Both engines are arranged to operate condensing, being fitted with independent condenser units of capacity equal to their rating. These condensers are of the jet type and were furnished by the Allis-Chalmers Co. Circulation water is taken from the river, an intake conduit being extended into the river at a point up-stream from the station, while the condenser discharge is delivered to the river at a point down-stream. These independent condenser equipments are duplicated by a novel arrangement of large capacity condenser unit which is connected to the exhaust steam header, the purpose being to provide a condensing equipment in duplicate of the smaller individual units, while also permitting of the operation of both engine units from a single large condenser in case both generators are in operation.

The generators are of the 3-phase alternating-current type, being installed in two 750-kw. units, each direct-connected to one of the cross-compound Corliss engines. They are of the revolving-field type built by the Westinghouse Electric & Mfg. Co., and are star connected with grounded neutral, delivering 2300 and 4000 volts at a frequency of 60 cycles. They are especially equipped for operation in parallel and each unit has an attached exciter of 22-kw. capacity. The two units have been in operation nearly a year, and have safely withstood large overloads, the load carried by the plant having grown at the present time to an average demand of about 1000 kw. A feature of the generator circuits is the connection to the distribution system on the four-wire system, a lead being connected in addition to the regular three-phase leads, to the grounded star neutral which permits of the delivery of 4,000 volts between phases, or 2,300 volts between any phase and the neutral.

The generator and distribution circuits are controlled on an eight-panel switchboard of which three panels are devoted to the generators and the exciters and five panels to the feeder circuits. The various panels contain the usual switch and instrument equipment for generator and feeder control. The five feeder circuit panels are each devoted to a single feeder circuit that extends to a feeding-in point in the low-pressure distribution network in the city. Each of these panels is equipped with indicating watt meters, ampere meters, recording watt meters, regulators for each phase and compensators to indicate the voltage at the end of the feeders.

The distribution system of the company is underground, an underground conduit system having been installed which covers practically the entire business district of the city. Connections from the plant to the distribution conduit system, are made through a 36-duct conduit line which provides amply for increases in the service. In all about 10 miles of conduit have been laid in streets and alleys in the city. Each of the five feeders from the switchboard feed into the 4-wire distribution network at different points through three 100-kw. transformers. These transformers have 4-wire 3-phase connections with grounded neutral, both primary and secondary, and are so wound that both single-phase, 115-volt current between phases and the neutral, and 3-phase, 200-volt current are available from the network.

Considerable economy and a great degree of flexibility has been secured, it is stated by the officials of the company, by the adoption of the four-wire system of three-phase distribution. The neutral lead has been made the same size as the other three line wires which increased the cost of the lead covered feeder cables about 12 per cent. over that if but the three wires had been used. But this permits the use of standard 2300 volts transformers connected from outside leads to the neutral, whereas if the neutral had been omitted, it would have been necessary to use special transformers or suffer from unbalancing in the system. Also in the secondary network a certain economy is effected by the 4-wire system by the smaller amount of drop. These advantages and the flexibility resulting from the possibility of running either single-phase or 3-phase connections from this system for any service outlet are considered to more than offset the increased cost of the neutral lead.

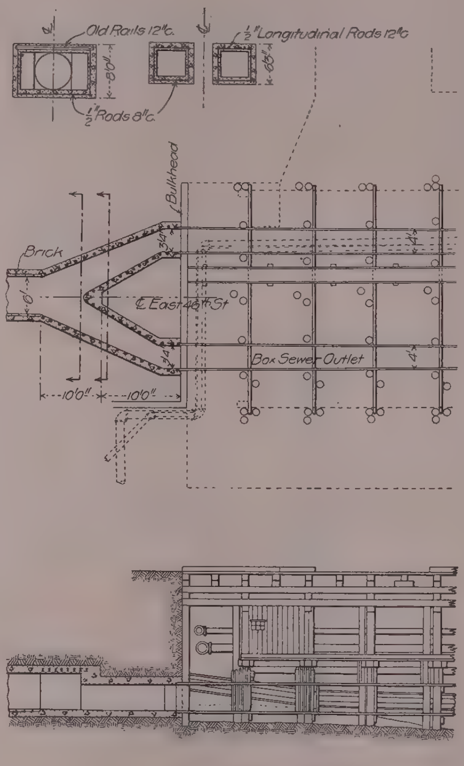
The power plant was designed by the Merchants' Power Co., of which Mr. E. G. Cowdery is president; Mr. L. G. Van Ness, secretary, and Mr. K. D. McKellar, counsel. The company was formed largely of local capital and is managed by a directorate of which three of the four members are by compulsion residents of Memphis.

A Private Sewer Tunnel in Rock Excavation.

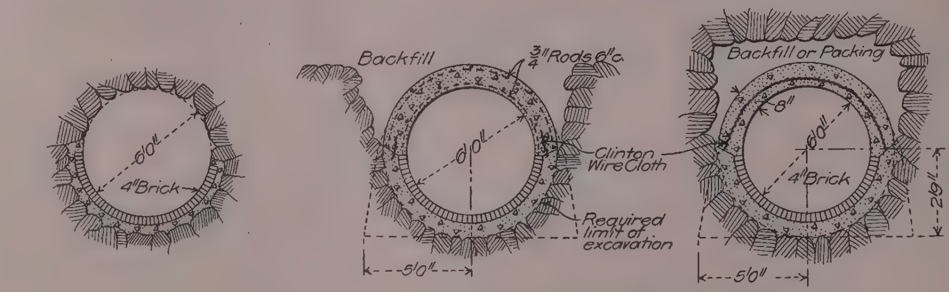
The depressed yard for suburban train service at the New York Terminal of the New York Central & Hudson River R.R. Co. occupies an area of about 24 acres at a level of about 45 ft. below the surface of the street. All of this area and a part of that of the 42-acre express yard 20 ft. above it is served by a private sewer which discharges the storm water through an outfall in the East River about 3,000 ft. away. The sewer is built on a tangent on the center line of 46th St. and extends from Madison Ave. to the outer end of the city dump pier east of 1st Ave.

Across the suburban train yard, a distance of 475 ft. the sewer has an egg-shaped cross section 32 in. wide and 48 in. high and is made of concrete with the invert lined with one course of brick on edge and the arch reinforced with one sheet of Clinton wire cloth. Beyond the east retaining wall of the suburban yard the sewer has a circular cross section 6 ft. in diameter inside and is made with 1:2:4 Atlas Portland cement concrete with a minimum thickness of 12 in. The invert has a semi-cylindrical lining of a single course of hard-burned red brick laid on edge and, where the rock is unsound, the arch is reinforced with one sheet of Clinton wire cloth depressed at the crown to within 3 in. of the intrados and extended to the middle of the wall at the skewback, where it overlaps the brick invert about 12 in.

Near each street intersection it is provided with a vertical brick man-hole, 4 ft. in diameter intersecting an arc of about 80 deg. of the upper quadrant of the circle. The sewer is run at a 0.2 per cent. grade, which gives it a maximum depth of 45 ft. from the surface of the ground to the bottom of the invert and carries the extreme river end of the outfall to a point about 1 ft. above mean low water.

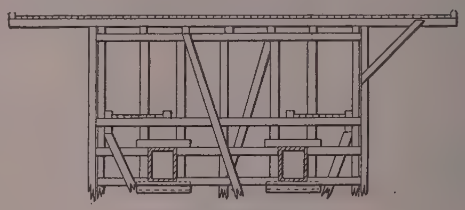


Tunnel and Outlet Connection.

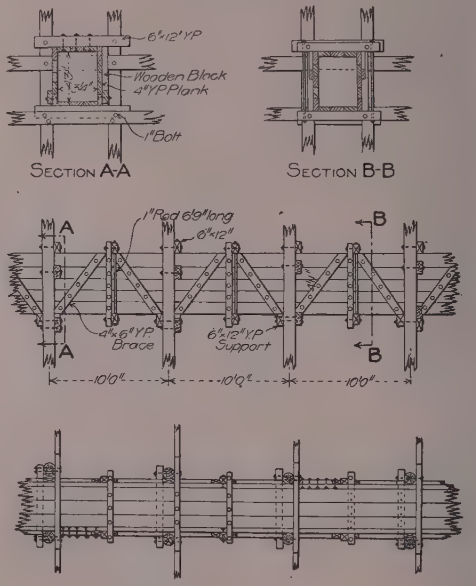


Sections in Hard Rock, Open Cut and Soft Rock.

The outfall is carried about 300 ft. beyond the bulkhead line through the sub-structure of the pile pier which supports it. As the spacing of the piles and bracing would not clear the full-size cross section of the sewer the regular construction was terminated on the shore side of the bulkhead, where it is joined with a reinforced concrete Y to a pair of rectangular closed wooden flumes 40 in. wide and 51 in. deep inside and 18 ft. apart on centers. This section is made with 4-in. square-edge yellow pine planks breaking joints and supported on pile bents 10 ft. apart by horizontal beams under them. In each panel between pile bents a pair of 4 x 6-in. yellow pine inclined posts are bolted to the outer surface of each vertical side of the flume with their lower ends resting on the sills or floor beams so as to make a sort of A-shaped reinforcing truss with a center vertical yoke piece to which top and bottom horizontal pieces are bolted. The upper horizontal piece rests on the upper ends of one pair of inclined braces and is connected with the lower horizontal piece by vertical rods thus acting to transfer the dead and live load of the flume directly to the pile bent.



Twin Outlets in Pier.



Trussed Wooden Outlet.

Between Lexington and Second Aves. the sewer is located in the same vertical plane as a 4 x 2 ft. 8-in. brick sewer about 10 ft. in the clear above it and in the same plane as a 15-in. pipe sewer between Second Ave. and the river. Under the pier there is an existing wooden box sewer and an 8-in. and a 12-in. intake pipe, all of which had to be cleared or shifted for the new sewer.

The location of the sewer is through hard gneiss rock except for about 300 ft. at the river end where it is in mud and earth, and for a short distance near the middle where the upper part rises above the natural rock surface.

Connections of Headings from Shafts C and D.

Construction was commenced about the first of last April, and four rectangular shafts were sunk to the invert on the center line of 46th St. at the points where the permanent man-holes are to be located. In order to secure the greatest economy in excavation and operation, the shafts were made somewhat larger than the minimum requirements for construction and it was intended to have them about 5 ft. wide and 8 ft. long, dimensions which were slightly exceeded at the Third Ave. shaft. The upper parts of all the shafts intersect the trench of the existing sewer and are carried through back-fill which is retained by ordinary sheeting; below the bottom of this trench the remainders of the shafts are in rock which does not require timbering.

The blasting holes in the shafts were drilled with six Ingersoll-Rand M.F. hammers, capable of making a ⅞-in. hole 4 ft. long. These tools resemble an ordinary pneumatic hammer, and as they did not require any tripods or standards but were held directly in the hand, were found very effective and convenient although not quite light enough to be satisfactorily used for driving horizontal and inclined holes in the tunnel where they were found less desirable than the standard column mounted rock drills. Although the shafts were blasted with very light charges of dynamite, the concussions were severe and a large amount of window glass in the vicinity was broken by them.

The work on shaft No. 3 was considerably delayed by the fact that it was close to a public school and blasting was prohibited during school hours for fear of alarming the younger pupils. Considerable annoyance was due to the water which collects in the trench of the existing sewer and, of course, flows into each of the intersecting shafts. Some water was also encountered in the seams of the rocks, but all of it was readily removed by a Cameron steam pump with a 3-in. discharge pipe in each shaft. Above each shaft is erected a 15 x 20-ft. heavy rectangular timber tower about 15 ft. high with four of the eight vertical posts seated on one curb and the other two just beyond the center line of the street. The top of the tower is decked over and on it is seated a boom derrick operated by a two-drum Lidgerwood hoisting engine driven with compressed air. The derrick boom is fixed vertically so that it does not require to be topped up and the mast is located so that the arc described by the end of the boom intersects the center line of the shaft and of the hopper bottom elevated storage bin which has a capacity of about 6 cu. yd.

Muck is hoisted from the tunnel in ½-yd. cylindrical steel buckets which dump it into the storage bin where it remains a short time until it is convenient for the wagons in the street below to drive underneath and be loaded through inclined chutes. This saves all handling of the material, avoids obstructing the street or delaying the wagons, and enables the muck from all the tunnel to be advantageously delivered by three wagons to the public dump at the foot of 40th St., making an average haul of about 3,000 ft. A portion of the tower at the top of each shaft is enclosed and the high, tight board fence is extended a short distance to the middle of the street to form a storage yard for supplies, and contains in some cases a smith shop for executing simple repairs, sharpening drills, etc.

West Heading at Shaft D.

Headings were driven in both directions from the feet of all the shafts and were worked in the usual manner for simple rock work, the drilling being done with nine Ingersoll-Rand B24 drills and six Sullivan UE No. 2 drills, all operated by air at about 100 lb. pressure delivered through a surface pipe from the power plant at the Grand Central Palace about 500 ft. from the west end of the tunnel, where there are installed two Chicago Pneumatic Tool Co.'s compressors with a capacity of 1,050 cu. ft. of free air per minute each.

The delivery pipe is 6 in. in diamter up to the first shaft, beyond which it is successively reduced to a final diameter of 2 in. It crosses Lexington Ave. with an overhead loop made with two vertical pipes about 18 ft. high and 35 ft. apart, set just outside the curb lines and connected with top and bottom tees to the horizontal main above and below the street. The 35-ft. overhead horizontal pipe is queen-post trussed with a pair of ¾-in. horizontal rods passing over two vertical plank braces at the 1/3 points of the pipe, and having end nuts engaging beveled bearings at the ends of the pipe just outside the connections to the vertical. The tee connections for the buried horizontal pipes at the lower ends of the main verticals have 4-ft. extensions below the latter which are bedded in solid pedestals of concrete, thus giving the loop sufficient stability to maintain itself above the roadway without bracing or guides.

The pipe crosses Second and Third Aves. with vertical rectangular overhead loops of a reduced diameter which, however, are suspended directly from the elevated railroad structure and therefore do not need the trussing and foundation pedestals used for Lexington Ave. At the First Ave. crossing the pipe is carried in a trench under the roadway.

The full-sized headings are drilled with 8 holes for the first shot and 10 for the second shot, all of them 8 ft. long. At first these holes were drilled in both of the 10-hr. shifts, by two drills set on one column. Later it was found more advantageous to set three drills on the same column and drill all the holes by one shift of miners, who fired them, and left the mucking to be done and the columns to be set ready for repeating the same operation in the second 10-hr. shift. The best progress made was 30 ft. in one week for one heading or 124 ft. in one week for eight headings. Many delays were experienced on account of ordinary interruptions and the inefficiency of the labor.

Each heading required four or six drillers and helpers, usually negroes, and two muckers, usually Italians. The drillers were not generally careful or reliable and created very large expense bills for breakages. Owing probably to the small dimensions of the tunnel an unusual amount of difficulty was experienced from the fumes of the dynamite, and after each blast it was necessary to open a valve and allow the compressed air to escape for some time to blow out the smoke, notwithstanding which occasionally the entire force of miners would be disabled for a short time by the fumes.

The muck was loaded into ½-yd. steel buckets seated on ball-bearing, steel-frame flat cars which when loaded were easily pushed by two men on the light 24-in. gauge single track, although it required four men to push with difficulty an ordinary car with the same load. Both cars and tracks were furnished by Mr. Arthur Koppel. Care was taken to excavate as little as possible beyond the neat lines of the tunnel construction, but the rock was so irregular, with occasional hard places, that it was difficult to blast it with accuracy and very often the 8-ft. holes would only pull out 6 ft. of rock.

No preliminary borings were made. At the Third Ave. shaft the rock surface was encountered about 16 ft. below the surface dipping westward. Test holes were therefore driven in the roof as the west heading progressed, which indicated that the rock surface would drop below the tunnel arch. To determine to what extent the rock surface would dro below the tunnel grade, exploration borings were made from the surface, indicating that there is little or no roof for a distance of 270 ft. westward from the east line of Third Ave., and that in one place there is a deep fissure extending below the top of the tunnel, so that, considering the character of the ground and the amount of water, it would be difficult or impossible to drive the tunnel under atmospheric pressure, and a section 180 ft. long has been provided with air locks at both ends and is now being driven under an air pressure of about 8 lb. to complete the excavation.

The air lock at the east end is a steel cylinder 6 ft. 4 in. in diameter and 10 ft. long set in solid concrete and carefully centered on the tunnel axis, so that after its removal the concrete will serve for the permanent tunnel lining. This lock was brought down in sections and assembled with bolted joints so that it can be readily removed without tearing out the concrete. The other lock is made with two end diaphragms 6 ft. 4 in. in diameter, each of which was received in two portions and was assembled in position 12 ft. apart after the concrete tunnel lining had been completed between them, thus serving to form the cylindrical part of the lock and obviating the use of steel plates for that portion of it. After the excavation has been completed all the metal work on both locks will be removed, the grooves occupied by it will be filled with concrete and the brick invert laid on it completing the tunnel section with a minimum disturbance. Excavation is being made beyond the lock under an air pressure of 8 lb. which is maintained by an ordinary steam reducing valve set on the high-pressure supply pipe for the drills. Care is taken to drive vertical sounding holes about 8 ft. apart in the tunnel roof so as to always determine the thickness and character of the rock there. The timbering in parts of the tunnel where the rock was soft or the roof thin, amounts to about 200 lin. ft., and was made with 8 x 8-in. vertical pieces and caps from 2 to 5 ft. apart supporting short longitudinal roof planks.

The regular rock tunnel section in sound rock requires about 1½ cu. yd. of excavation, 12 cu. ft. of concrete and 70 bricks per lineal foot. After the excavation is completed a bed of concrete about 3 ft. wide is spread on the bottom of the tunnel and on it are set and firmly bedded 5-ft. sections of Blaw collapsible centering, each made with a thin semi-circular steel plate with stiffening angles at the upper edges held together with two horizontal diametrical tension rods adjusted with sleeve nuts. The sections of centering have inside lap splice plates with pair of slotted holes in one edge to receive projecting eyes in the adjacent edge, which are locked in position with inside wedges through them. The centers are accurately set and finally secured in position by vertical struts bearing against the roof of the tunnel and form an excellent platform on which the concrete is hand mixed and from which it is shoveled into the spaces on each side of the form, filling all the irregularities up to the rock surface. After the concrete is set the brick invert is laid whenever convenient, two bricklayers being able to lay about 60 lin. ft. in 8 hr., equivalent to fully 4,000 bricks. Where the rock is not sound a reinforced roof is specified, which it is proposed to build with the same centers used for the invert.

Air Lock in West Heading.

About 300 ft. of the east end of the tunnel was built in open trench sheeted down to a maximum depth of 30 ft. by ordinary methods. The sheeting was placed in two tiers of square edge 2-in. planks, driven down and braced as the trench was excavated. The upper tier is about 16 ft. long and the lower tier about 12 to 14 ft. long. This trench exposed the old 15-in. vitrified pipe sewer which was found very badly broken and was replaced by a new pipe sewer discharging into the 6-ft. sewer at the foot of the First Ave. manhole. The flow of the old sewer was temporarily carried through a wooden box supported on shores or suspended from the bracing until the new sewer was completed and the trench partly back filled when it will be more convenient to lay the new sewer in a concrete bed.

Two columns of the elevated railroad structure are located over the tunnel where it crosses Third Ave., and in order to prevent any possible danger of settlement or undermining in the soft soil there, the structure was underpinned by the elevated railroad employees before the tunnel excavation was commenced at this point. A pair of long, heavy plate girders perpendicular to the axis of the tunnel were set side by side on each side of Third Ave. at its intersection with 46th St. and carry timber crib-work towers extending up nearly to the under side of the elevated railway girders where they carry a pair of transverse plate girders about 6 ft. apart on centers, spanning Third Ave., one on each side of the permanent transverse girder of the elevated structure. These girders are wedged up to bearing on the transverse girders so as to support it and its two columns and afford ample security for the structure in case of any settlement or disarrangement of the soil below.

The junction of the rectangular twin wooden outfalls with the concrete sewer was built in an open cofferdam made with 2-in. square-edge sheet piles which serve merely as a retaining wall and were not intended to be absolutely water-tight, work being restricted for this part of the construction to a period of about 3 hours at low tide, when the bottom of the excavation was at a maximum height of 1 ft. above the water level.

The excavation has been completed except for a very small portion of open trench and part of the tunnel between the air locks. The construction of a concrete lining and of a brick invert has been commenced and the wooden outfall and its junction with the concrete tunnel has been completed. A total force of about 75 men is at present employed who all work two 10-hr. shifts, except under air pressure, where there are three 8-hr. shifts. When excavation was in progress at all of the headings simultaneously the maximum force was about 200 men. The sewer has been designed and constructed under the direction of the engineering department of the New York Central & Hudson River R.R., Mr. G. A. Harwood, chief engineer of the Electric Zone; Mr. W. L. Morse, terminal engineer, and Mr. St. John Clark, consulting engineer. The contract was awarded to the Terry & Tench Construction Co., Mr. E. B. Naylor, engineer in charge.

Forest Reservations have been made in British Columbia by the Canadian Government, of all unleased timber land, amounting to 150,000,000 acres.

The Sanitary Campaign in California.

An extremely thorough and conscientious sanitary campaign is being conducted in practically all of that part of the state of California west of the Sierra Nevada Mountains in an endeavor to prevent the reappearance of the bubonic plague during the coming summer. Most of the sanitary measures thus far recently enforced in this connection partake of the nature of emergency work. The campaign contemplates, however, the inauguration of permanent regulations designed to improve the existing sanitary conditions of the various communities most liable to the importation of the plague, as well as to prevent outbreaks of the disease in the immediate future in localities where infection is known to be present. In fact, the general plans for improvements already being executed are so broad that if they are carried to the ends proposed even the infected localities can certainly be relieved of any danger of numerous cases of the plague with the return of warm weather. The complete execution of these plans will also eliminate any possibility of a spread of the disease and will result in continuously increasing safeguards against future danger of a spread of imported infection.

The campaign is under the direction of members of the United States Public Health and Marine-Hospital Service, the Government providing part of the necessary funds for San Francisco, while the different cities and communities furnish their own funds in various proportions, dependent on local conditions. The work in the entire state is under the command of Past-Assistant Surgeon Rupert Blue, of the Public Health and Marine-Hospital Service, who is also personally directing the forces in San Francisco. Past-Assistant Surgeon J. D. Long, of the Service, is in immediate charge of the campaign in Alameda and Contra Costa Counties, in which counties are located the cities of Oakland, Berkeley, Alameda and various smaller communities, with also a large rural population. The remainder of that part of the state in which there exists a possibility of a spread of the disease, in case an outbreak should occur, is divided into districts of various sizes, each district being in charge of an officer of the Service.

Organizations perfected in the various districts have executed the measures adopted, in so far as funds have been available. Arrangements have been, or are being made, however, to provide all the necessary funds for emergency work, and in many cases for executing the chief features of the plans for permanent improvements. For instance, in San Francisco the Federal Government is spending over $1,000 a day, a citizens' committee is contributing approximately the same amount, which is provided by private subscription, and the city is extending such support as the present condition of the city treasury will permit. At the same time, since the ultimate success of whatever may be undertaken depends so greatly on the individual resident an extensive amount of educational work must be done before sufficient realization of the value of the adopted and proposed measures can be brought about to obtain the personal assistance of all of the inhabitants of the different cities and communities. Such educational work has been carried on over a wide range, organizations in every class of society having been reached, with surprisingly good results.

The nature of the plague and the manner in which it is spread have until recently been understood by a remarkably small percentage of people, even in the localities where cases of the disease have occurred in considerable numbers. This ignorance of the situation has been greatly relieved by the local press in most of the cities which are chiefly concerned, and by the educational work done among various organizations. Naturally, some opposition to publicity of the presence of any possibility of danger from the disease, for immediate commercial reasons, has resulted in a hesitancy on the part of various papers to assist in making known the gravity of being unprepared to meet emergencies that may arise. In some cases also a few papers have been reluctant to discuss the characteristics of the disease and the means by which the latter is transmitted. This opposition has, fortunately, almost entirely disappeared as the results of the sanitary work that has been undertaken have become apparent, and the ruinous effect on business that would be brought about by an ultimate quarantine has been better understood.

The plague occurs in four more or less distinctive types, all of which are caused by one kind of bacteria, the method of infection determining to some extent, if not entirely, the type of the disease to which a victim is subjected. The bubonic type, affecting the various glands of the body, is by far the most common. The other three types are the pneumonic, septicemic and intestinal, which as their names imply, respectively affect the lungs, blood and intestines. The symptoms and results of the two latter types are quite generally the same. In fact, the three latter types are all similar in their general characteristics.

The bacteria of the disease are quite readily isolated, since they respond to several distinctive reaction and staining tests. They are bi-polar organisms of a fairly hardy nature, with the result that they can withstand conditions diverse from those in which they thrive best. They will also retain their general characteristics through long periods of adverse conditions. At the same time, when bacteria of a degenerated nature, as to speak, are transmitted to a victim they increase in virulence with each succeeding infection until they become extremely active.

The bubonic type of the disease requires some intermediary to transmit infection from one victim to another. The other types are somewhat more directly communicable under certain conditions, but are much less frequent in occurrence, due to a normal lack of the proper conditions for their transmission. The common house rat being very susceptible to all forms of the disease, presents the greatest menace towards the spread of the latter. Generally speaking, all of the rodentia are likewise susceptible to the disease, although their habits are such that compared with the rat they offer little danger to a community.

The disease is communicated from the infected rat to man by means of several species of fleas, particularly the *Pulex Cheopis*, which is found on rats throughout the world. In San Francisco and Oakland, the most common flea on the rat is the *Ceratophyllus fasciotus*, about 75 per cent. of all the fleas taken from the rats in those cities and vicinity being of that variety. Of the remainder, 10 per cent., more or less, are *Pulex Cheopis*, about 5 per cent. *C. Musculi;* 5 per cent. *C. Canis*, and 5 per cent. *Pulex irritans*. All of these fleas which infest the rat will also bite man. In tropical countries fleas are found on rats in large numbers during all the year, but in a climate like that of California rats are almost entirely free of fleas during the cooler winter months. As rats habitually congregate in large numbers and migrate at the least provocation, fleas are readily carried from an infected rat to other rats, even at considerable distances.

Since fleas of all species bite man as readily as they do a rat, infection is thus transmitted to the human victim. Before the flea can drink the human blood it is necessary for the insect to inject a fluid into the incision made with its cutting mandibles which will thin the blood. Consequently, if a flea from an infected rat bites a human victim the latter receives an injection of a large number of plague bacteria. Furthermore, when a flea makes an incision it also excretes from its alimentary tract on the surface of the skin of the victim a quantity of fluid filled with plague bacteria. This observation is comparatively recent, as it was formerly considered that the flea from an infected rat merely washed some of the bacteria from his mandibles into the incision made to obtain blood. Investigations conducted under Dr. Blue's direction have determined definitely, however, that the alimentary tract of one of the insects from an infected rat is filled with bacteria.

On account of rats being almost entirely the sole means of spreading the infection, the efforts of the whole sanitary campaign have been directed towards first eliminating rats completely and then preventing an opportunity for them to reappear and breed. Existing conditions in various cities along the coast are particularly favorable to the propagation of rats, and in many cases adverse to their destruction. These conditions are being changed as rapidly as possible, immense numbers of rats having already been killed.

The plague existed in San Francisco from 1900 to 1904, inclusive, during which time it was confined entirely to the Asiatics. In this period 121 deaths from the disease are known to have occurred, although it is probable that the actual number of victims was much greater, since the symptoms and effects of the plague are difficult to identify under certain circumstances. A campaign carried on at that time under the direction of Doctors Kinyoun and Blue resulted in a complete subjection of the disease, although infected rats unquestionably remained. From 1904 until May, 1907, no known cases of the plague occurred in San Francisco. One case which resulted fatally occurred late in May, 1907, but there were no cases reported after that until Aug. 12, following. Between the latter date and Jan. 30, last, a total of 158 cases were recorded in San Francisco, with 77 resulting fatalities. Almost all the cases during this outbreak were among the whites, only four or five Chinese and and an equal number of Japanese being victims. From Jan. 30 to the time these notes were prepared no cases had been reported. With the approach of winter the rats became much less active, due to cooler weather, and the fleas left them almost entirely, on the same account. In fact, it has been determined that during January and February only one rat in six or seven had a flea on it, while during the warm months each rat may carry as many as thirty fleas, on an average. Hence the danger of the spread of the infection is correspondingly greater.

During the first four years when the plague was present in San Francisco no fatal cases are known to have occurred in Oakland, Alameda, Berkeley or the surrounding country. In the past year, however, twelve deaths from the plague have been recorded in Oakland, two in Berkeley and a few isolated cases have been known in other parts of the State. Of the cases in Oakland one victim was taken there from San Francisco, and there is reason to believe that all of the infection was transmitted from that city to Oakland and Berkeley by one means or another. The last death in Oakland occurred on Dec. 22 last, and no cases have been found there or elsewhere on that side of the bay since then.

The first efforts made last year by the United States Public Health and Marine-Hospital Service to check the disease in San Francisco were conducted from the middle of last summer until September under the direction of Dr. Long. The latter then took charge in the two counties across San Francisco Bay and was succeeded in San

Francisco by Dr. Blue, who also commands all the work in the state. The work was done by the Government forces and largely at the expense of the Government until the municipalities became aroused to the situation. Since then the Government has furnished a part of the funds and the remainder has been provided locally by various means, as previously mentioned.

In order to systematize the enforcement of sanitary measures, San Francisco has been divided into twelve districts, each under the immediate direction of an officer of the Marine-Hospital Corps. A separate organization is established in each of these districts to carry out the plans of the campaign, which plans are in general the same for the entire city. A rigid sanitary inspection is maintained and efforts are constantly directed toward eliminating the conditions favorable to the harboring and growth of rats. In all, a force of about 750 men is engaged constantly in the work being done. The majority of this force is laborers who have been employed chiefly in catching and poisoning rats, although a large amount of general sanitation work has been done by them. These laborers are under the supervision of foremen and the latter report to assistant surgeons in charge of the district in which they are located. In addition to the results accomplished by these forces a liberal bounty offered for rats by the city has occasioned a large number of men and boys to engage independently in rat catching. The entire resident population of the city has also, on the whole, made strenuous efforts to catch or poison rats, and to remove opportunities for them to feed. The captured rats delivered to the sanitary forces of the service are all cremated, whether they are infected or not. Instructions are also given to others capturing rats to dispose of them in the same manner.

A laboratory is maintained by the Public Health and Marine-Hospital Service in which a close check is kept on the conditions at all times by determining the number of infected rats delivered from the different districts. The efforts of the organization can thus be concentrated proportionately in threatened areas. At the same time, a large number of captured rats never reach the laboratory and many plague-sick rats die in the sewers or other similar places, so that general conditions in the district must be observed closely. Thus far it is evident that the infection among the rats is very widespread throughout the city. It is impracticable to determine exactly the percentage of infected rats, since the numbers received from the different districts vary so greatly from day to day, and also because only a portion of those infected are captured.

The climatic and other conditions in San Francisco are particularly favorable to the breeding and existence of rats in great numbers. Most of these conditions likewise apply to other cities in the vicinity and to the rural communities as well. Although the rats are much less active in the cooler winter months, freezing temperatures in the region in which the campaign is most needed are almost unknown, so the rats breed during most of the year. Next to these favorable climatic conditions the method of garbage collecting in San Francisco offers most favorable means of existence to rats. In addition, the large percentage of frame buildings, which are constructed, almost without exception, with no provisions to prevent rats from congregating in them, afford an excellent harbor for rats. Furthermore, the condition of the sewers in the burned districts is such that they also afford good feeding and living places for rats.

The garbage of the city is collected entirely by private team owners, who haul it to a private incinerator where they pay a certain amount per ton to have their collections cremated. Some owners have several teams and wagons, but most of the collections are made by men owning a single outfit. These collectors have regular customers who are secured and distributed in a manner similar to the customers of a private milk or ice delivery route, the various routes greatly overlapping. The charge for collection in general depends on the amount of garbage produced by the customer, the average householder paying 35 to 75 cents per month for a collection each week. Hotels, restaurants and so forth, pay $2.50 to $60 per month for the services of these collectors. The entire system is so regulated among the various collectors that the charges for collection are practically fixed. As a rough estimate, it may be said that about 70 per cent. of the population is served by these collectors, while the remainder cremate their own garbage, throw it into alleys or adjacent open areas, or bury it.

Various city ordinances intended to regulate the operations of the collectors and the disposition of garbage not delivered to the latter have been in force for some years. The existing conditions have heretofore made the enforcement of these ordinances particularly difficult. Consequently the system has produced anything but satisfactory results, from a sanitary standpoint. First of all, the time of collection is so infrequent that the stored garbage offers an excellent source of food for rats, unless the garbage is stored in tight metal cans, which has not been the case in the past, except in rare instances. Then the tendency for a considerable portion of the inhabitants to avoid the fee for collection by disposing of their garbage on their own or adjacent premises has increased the food supply for rats to a great extent. The collectors have also been tempted strongly to dump their garbage in convenient open areas, in order to avoid the long haul from certain districts to the incinerator, and particularly the cost of cremation at the latter.

These various unsatisfactory conditions have been overcome largely by recent ordinances drawn to eliminate them, in addition to those ordinances already existing. The enforcement of all ordinances relative to the situation is now under the direction of the inspectors maintained in connection with the sanitary campaign. All garbage is required to be stored in tight metal cans of a type required by ordinance and approved by the service, so that the principal former source of food supply for rats is being removed as fast as the tight cans can be provided. Garbage is also not permitted to be thrown on the ground, where a householder does not employ a collector to haul it away, and must be disposed of in a manner satisfactory to the inspectors. The private collectors are watched closely so that they do not dump their loads on outlying areas, instead of delivering them to the incinerator.

In addition to the results accomplished by improving the system of garbage storage and collection, other sources of food supply for rats have been largely eliminated. The merchants and food and grain supply dealers throughout the city have assisted in this connection. Ordinances controlling the storage of manure around stables to prevent the harboring and feeding of rats are also being enforced strongly. An effort is even being made to prevent droppings along the streets from the feeding bags of horses, and to induce laborers on the large number of buildings under construction around the city to avoid scattering scraps from their noonday lunches.

The ends accomplished by these various means have been quite satisfactory, as a large number of rats have been destroyed and conditions favorable to their harboring and feeding greatly eliminated. With the exception of the improvement in the means for the storage, collection and disposal of garbage, however, the work thus far done is more or less of an emergency nature. The plans for permanent improvements contemplate further changes for the better in regard to the garbage situation, particularly in connection with the strict enforcement of tight storage cans. It is further probable that the city will later undertake the collection and disposal of garbage. An effort will also be made to obtain an ordinance requiring all new buildings to be constructed with concrete floors on the ground and ratstops in the walls, which will prevent the harboring of rats in them; this means of prevention is possible at little additional expense. Other general ordinances of the same nature are also being considered. Under the circumstances, therefore, with the results already achieved the city is almost assured of little danger from the plague during the coming summer if the work started is continued and the further proposed precautions that have been outlined here are enforced, as they will all doubtless be. In fact, the efficiency of such work as is being done is evidenced in that during the outbreak last year no cases of plague are known to have occurred in the Asiatic quarter, which has been rebuilt since the fire according to the regulations proposed for the entire city, and is subjected to rigid sanitary inspection. This result is all the more striking in light of the fact that the former outbreaks were practically confined to this quarter. At the same time, since the least presence of plague-infected rats is always a menace, and the infection may be, and, indeed, frequently is retained for years among the rats before appearing in human victims, the broad general measures should be carried out as proposed by the Public Health and Marine-Hospital Service, and others familiar with the conditions.

The sanitary situation in Oakland is much the same as it is in San Francisco, outside of the burned district in the latter. The garbage collection system is practically the same in both cities. A municipal garbage crematory was erected some years ago in Oakland, but this crematory burned early in 1907 and has not been rebuilt. Since then the collectors have hauled the garbage to a flat, marshy area adjacent to the shore of the bay, and surrounding the site of the old incinerator. An immense pile of material that teems with rats has thus been collected. The city is preparing to build at once a modern incinerator adapted to the needs of the situation. Plans have been made to haul the garbage to sea until this incinerator is completed. The storage and collection of garbage is also closely regulated under the supervision of the inspectors of the municipal Health Department and other provisions have been made to remove all the principal sources of food for rats.

An organization perfected in Oakland under the direction of Dr. Long is conducting a campaign along lines similar to those of the one being carried on in San Francisco, the city being divided into seven districts, each of which is in charge of a physician.

Large numbers of rats have been caught and disposed of by the forces employed and by the residents, but on account of local conditions the decision was made to use poison over the entire city. Accordingly, a start was made at the rear and along the both sides of the city, with the idea of not only killing the rats, but also of driving them toward the water-front. Poison was placed freely in all possible rat runs, in a continuous cordon extending around the city, with the ends of this cordon at the water-front. The cordon was advanced each day and caused the rats to become panic stricken until they fled ahead of it. At the time these notes were prepared the poison line was closing down to the water-front, with the result that the number of rats along the latter was increasing at an exceedingly rapid rate. When the line had nearly reached the shore it was proposed to concentrate all efforts toward capturing or destroying all the rats in the confined district. Meanwhile, rat catching and poisoning is being continued unabated in the entire city, although a large percentage of the rats had advanced with the continuous poison line.

The work in Berkeley, Alameda, San Jose, Sacramento and various other cities has been conducted chiefly by the municipal officials, under the direction of the members of the local boards of health, advised by members of the Marine-Hospital Service. The garbage situation in Berkeley, Alameda and San Jose is practically the same as it was in Oakland, but in all of these places plans are being made to make immediate emergency improvements and then, as soon as possible, to install incinerators, or other satisfactory means of disposal. A campaign of education to make known the local conditions favorable to a spread of the plague and the nature of the latter is being conducted by various local organizations and individuals in the different communities and cities. On the whole, therefore, the entire region around San Francisco Bay is so fully aroused to the situation that little danger is present of outbreaks of the disease during the coming summer, or of a spread of the disease should it appear. The execution of plans for permanent improvements tending to eliminate the existing unsatisfactory sanitary conditions after the emergency measures are fully enforced will also render very remote any danger of a transmission of plague in the future.

Underpinning a Quay Wall.

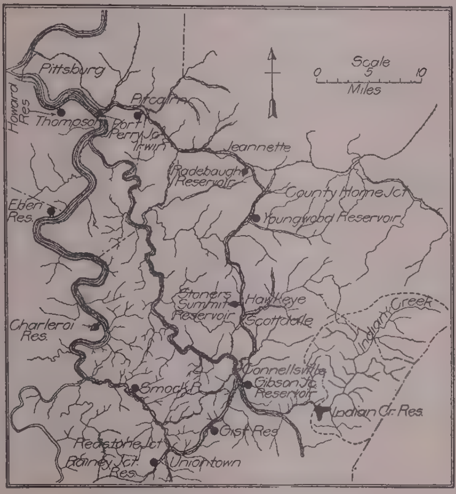
Quay wall underpinning has been necessary in connection with the harbor improvements at Blyth, England. The original wall was built many years ago and when the new works were undertaken its base was found to be defective and undermined to such an extent that the diver was able to crawl underneath the wall in many places. As in addition to this the river bed is to be deepened 10 ft., special precautions were necessary to make the wall secure. At the present time 300 ft. of the work has been completed and the remaining 400 ft. will shortly be taken in hand. Clay was deposited in front of the wall and through it piles were driven, continuing 18 in. into a very hard stratum below. A dam of clay and gravel puddle was then deposited outside of the sheet piling, the inside of the cofferdam drained, the clay removed from the inside and struts put in to brace the sheeting against the quay wall. A crane track was built on a trestle on the outside of the cofferdam. The latter proved to be very tight but a considerable amount of water entered from the back of the wall. This was removed by three electrically operated centrifugal pumps each delivering 500 gal. per minute. The whole of the old base of the wall was removed and replaced by concrete 6 ft. in minimum thickness, the new portion being tied back by heavy bolts grouted into the side rock. The bottom of the new base was 34 ft. below the level of high tide. In order to avoid the disturbance of the new masonry in the subsequent removal of the rock in deepening the channel a trench 5 ft. wide, extending to the full depth of the proposed new bottom, was cut in the rock immediately in front of the wall, extending the entire length of the new work.

A Violent Wind overturned four passenger cars on the Colorado & Southern Railway on Dec. 24, 1907, according to the "Railroad Gazette." The accident occurred near Marshall, Col., in open country a few miles from a range of high mountains. The track had 80-lb. rails, good ballast and was well drained, so that the overturning of the cars was unquestionably one of the rare accidents to standard-gauge cars from this cause. Narrow-gauge cars have been blown over a number of times, but not those of wider gauge and greater weight.

Indian Creek Water Supply System.

By J. W. Ledoux, Chief Engineer of the American Pipe Manufacturing Co.

By far the most elaborate and comprehensive system of water works ever undertaken for a like purpose has recently been put into operation for the Pennsylvania Railroad along its lines between Philadelphia and Pittsburg. Up to this time the water supply along the Pittsburg, Southwest and Monongahela Divisions of the Pennsylvania R. R. was, as has been so common with other railroads, very precarious. Many of the streams utilized were so highly charged with sulphuric acid from coal-mine drainage that an ordinary drought would so concentrate the corrosive qualities of the water as to render the locomotives using it unfit for service in a few weeks. During the dry summer and fall of 1904, before the new water supply was introduced, the loss from this cause, and the consequent inability to move trains, ran into the millions of dollars. President A. J. Cassett had foreseen the great danger to the railroad due to neglect of its water supply, and had undertaken with his accustomed vigor comprehensive measures to install a water supply of good quality and ample quantity for the entire railroad system for fifty years hence. The Indian Creek system herein described is one of the many water-works projects between Philadelphia and Pittsburg successfully carried out and built under his régime since 1903.



Indian Creek Water System.

On account of their large experience in water supply, The American Pipe Manufacturing Co. in 1902 was selected to make an investigation of the water supply conditions of the district including the Pittsburg, Southwestern and Monongahela divisions, and upon consideration of the needs of the railroad and all the practical and available supplies, Indian Creek was finally recommended as the most feasible, and The American Pipe Manufacturing Co. was engaged to make plans, purchase land, develop the water supply and construct the entire water system. Under these arrangements work was begun in the early part of 1903.

Indian Creek is located in Fayette County, Pa.; it rises near Ligonier and flows westerly to the Youghiogheny River, into which it empties at the village of Indian Creek on the Baltimore & Ohio R. R. This stream is one of the very few in that vicinity which is uncontaminated by coal-mine drainage, and it has for many years been recognized as a valuable source of water supply. As far back as 1889 it was seriously considered as a water supply for the City of Pittsburg, and during that year the writer made a personal investigation of the territory in the vicinity of Donegal, Stahlstown and Jones' Mill, and afterwards made for Mr. C. W. Knight, the hydraulic engineer, under whom he was then employed, a preliminary report and some calculations on the cost of carrying from this source a daily supply of 10,000,000 gal. of water by gravity to Pittsburg. After this Mr. Knight continued to make investigations of this stream and the drainage area, and established on it one or more weiring stations, and finally organized the Mountain Water Supply Co. for the appropriation of the waters of Indian Creek.

In 1889 Mr. Allen Hazen, who was employed by the City of Pittsburg to report upon its water supply, engaged Mr. Emil Kuichling to report on the feasibility of obtaining water from Indian Creek. Mr. Kuichling's report is embodied in Mr. Hazen's report to the Commission, but the City of Pittsburg decided to continue taking water from the Allegheny River, and considered it possible and more economical to purify that water by slow sand filtration.

The drainage area of Indian Creek above El. 1,250 is approximately 109 square miles. Most of the watershed drains the north slope of the Laurel Ridge which is quite well covered with timber, and the main stream flows along the foot of the ridge and is largely made up of smaller streams emanating from it. The watershed on the southern side of the stream is to a considerable extent cultivated, but there are several branch streams flowing from this side whose watersheds are well covered with timber. The entire territory is sparsely populated, none of the villages has more than two or three dozen houses, and the entire population of the drainage area does not exceed twenty-five persons per square mile.

Analyses of Indian Creek Water; Parts per Million.

	June 7, 1906.	Feb. 17, 1908.
Total solids	52.	....
Volatile solids	19.	....
Fixed solids	33.	....
Free ammonia	0.010	0.046
Albuminoid ammonia	0.052	0.052
Nitrogen as nitrites	0.000	Trace
Nitrogen as nitrates	0.00	0.64
Chlorine	2.0	0.17
Alkalinity	20.0	....
Iron	0.6	....
Sulphuric acid	2.7	....
Bacteria per cubic centimeter		664

The total solids, according to the 1906 analysis, consist of 33.5 parts per million of incrusting material, made up of 5.4 parts iron and alumina, 3.2 parts of silica, 4.6 parts of calcium sulphate, 11.3 parts of calcium carbonate and 9 parts of magnesium carbonate; and 18.5 parts of non-incrusting material, comprising 3.2 parts of sodium chloride and 15.3 parts of organic and volatile matter. None of the bacteria found in the 1908 analysis was characteristic of human discharges.

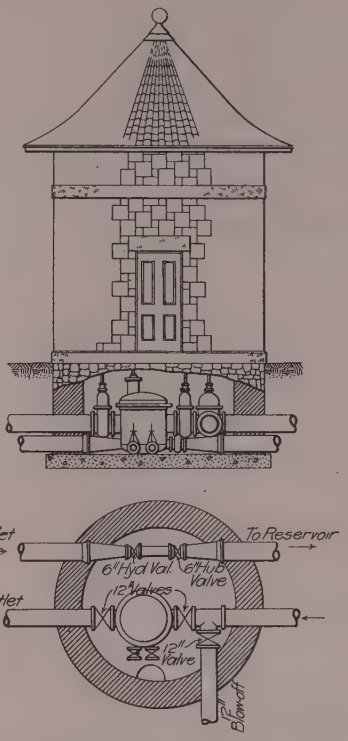
"From the above it will be noted that no bacteria of sewage contamination were found, and nearly all of the organisms found in the sample submitted were of common species which do not grow at blood temperature. Only 3 organisms per cubic centimeter developed at 98 deg. F., which is about the normal temperature of blood, and the organisms which do not develop at this temperature could not be injurious to those drinking the water. The chemical examination shows the water to be very low in chlorine, nitrites, nitrates, free ammonia and albuminoid ammonia, indicating that the amount of organic material present in this water supply is very small."

A reservoir holding approximately 231,000,000 gal. was constructed at a point on Indian Creek where the elevation above tide is 1250, and from there a 36-in. pipe was laid nearly along the line of the stream to Indian Creek village, and from there it deflects to the north and runs to a point known as Gibson Junction, about 2 miles to the south of Connellsville, where a distributing reservoir holding 6,000,000 gal. was constructed at El. 1222. From there the line continues 36 in. to meet the Southwestern Division of the Pennsylvania R. R. at a point about 2 miles north of Connellsville, and follows along this railroad northerly to a place called Hawkeye, near Stoner's Summit, where a reservoir holding 13,000,000 gal. was built at El. 1200. From this point along the Southwestern Division of the Pennsylvania R. R. to Radebaugh, via. County Home Junction, the line is 30 in. in diameter, and at Youngwood about half a mile from the line and connected therewith a distributing reservoir holding 1,000,000 gal. was built for the local supply for this Southwestern Division at Youngwood. At Radebaugh there was built a distributing reservoir holding 8,500,000 gal., and from this point the 30-in. line extends along the main line of the Pennsylvania R. R. westerly to Grapeville, Jeannette and Irwin to Pitcairn, where there was constructed a steel standpipe 100 ft. in diameter by 30 ft. high. West of Pitcairn the line is then reduced to 24 in., and extends as far west as Port Perry Branch Junction. From this point a 20-in. line runs across the Monongahela River to Thompson, and from there a 12-in. line extends west along the Monongahela Division of the Pennsylvania R. R. to a point near Howard, where a distributing reservoir was built at El. 887. From Thompson southerly along the Monongahela Division there extends a 12-in. pipe line to Redstone Junction, and from there along the Southwest Penn to a point near Gibson Junction reservoir there extends a 20-in. pipe line, making a complete circuit. On the Southwest Penn and Monongahela Divisions there were connected with the pipe lines the following reservoirs: A 2,800,000-gal. reservoir known as the Gist reservoir near Mt. Braddock; at Smock a 2,000,000-gal. distributing reservoir; at a point three miles east of Charleroi a 7,235,000-gal. reservoir, and at a point near Elben a 2,000,000-gal. reservoir known as the Elben reservoir. There is also a 12-in. branch running from Redstone Junction, via Uniontown, to Rainey where there was constructed a 2,000,000-gal. reservoir at El. 1102.

With the storage provided by the Indian Creek Reservoir the stream is estimated to yield in the driest season up to about 15,000,000 gal. per 24 hours. The dam was built of a solid gravity section, founded on bed sandstone rock; the maximum height is 40 ft., and the length is 763 ft. The upstream and downstream faces of the dam were composed of large rubble masonry with horizontal and vertical joints and rock faces. The space between these facings was composed of 1:2:5 Portland cement concrete having embedded in it as large a proportion as possible of stones averaging in size about half a yard each. The stones for all purposes were obtained from a quarry located close to the south end of the dam; the concrete stone was all that passing through a 1½-in. screen, and that passing through a ½-in. screen was used with that produced by sand crushers to make up the sand used in the masonry. The concrete was mixed by means of Smith and Ransome mixers; the batches and all the large stones were handled by means of derricks and tram cars running on tracks along the side of the dam.

The excavation for the south end of the dam was first completed, and the lower portion of the dam was then constructed to a point near the center of the stream, and then by means of coffer dams the stream was spanned and the water compelled to flow through the 36-in. discharge and 48-in. blow-off pipes. These ordinarily took care of all the water, and on one occasion where their carrying capacity was insufficient, the water was allowed to run over the top of the unfinished dam, which it did without damage or serious inconvenience. The dam was finally covered with sandstone coping 1½ ft. thick.

There were several parts of the foundation rock which by test were found to be more or less porous. The method of testing and correcting this difficulty was as follows: With the steam drilling machine, holes were drilled to the depth of 10 to 20 ft. below the bottom of the foundation, and with hand pumps water was forced into these holes under pressure, the suction pipe being kept in a barrel maintained constantly full. While pumping, the water could be seen flowing out from the cracks in the rock, then pure cement was stirred into the suction barrel until the grout thus formed became as thick as could be pumped readily, and the pump was not stopped until the increased pressure made it too laborious to longer move the pump levers. In some cases the holes were not more than 4 ft. apart. Three or four days after a series of holes was treated in this manner, a second series was drilled parallel to the first row and breaking joints with it, and these were treated in a like manner. As a general thing it would be difficult to pump grout into the second series, because the spaces in the rock would be filled up with grout from the previous line of holes.

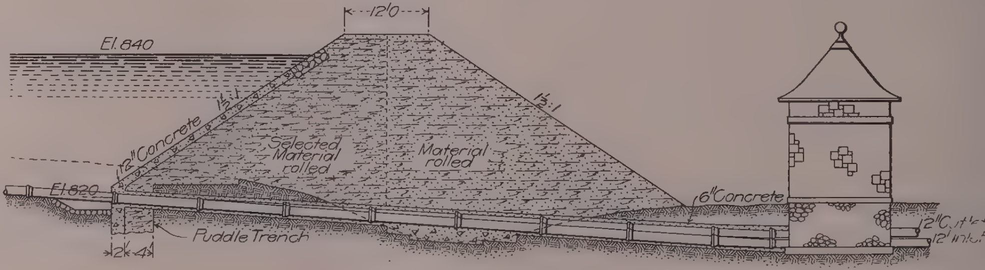


Charleroi Gate-House.

After the dam was completed and full of water, it was found that there was no noticeable leakage from below the foundation, but during the first winter, which was very severe, several vertical temperature cracks took place in the masonry. These, although not serious, were grouted in a manner similar to that described for the foundation, and in the spring they had disappeared from sight, and did not again reappear. In front of the blow-off and discharge pipes were placed vertical sliding cast-iron gates each operated by means of a hand-wheel and rising screw working in a pedestal fastened to the top of the dam coping. In the gate house on the downstream side of the dam are located all of the main gates which are operated by means of pistons within hydraulic cylinders into which water is pumped by hand force pumps, the discharge and waste from these cylinders being directed by means of 1-in. three-way valves. This is found to be easier than the ordinary method for operating very large valves, and in this case it was intended to operate them by means of water taken from a spring at an elevation high enough to produce sufficient pressure. This, however, has not been done.

The 36-in. line between Indian Creek dam and Connellsville proved to be a very difficult piece of construction. The first plan was to lay the pipe line along the Youghiogheny River side of the Baltimore & Ohio R. R., but this railroad company made strenuous objections to this position, and the matter was finally compromised by constructing the line on the side of the mountain to the east of the railroad. On account of the roughness of the country and the inaccessibility of the pipe line it was necessary to build a tram road from Indian Creek dam the entire distance to within 2 miles of Connellsville. In some cases the mountain slopes were very precipitous, inclining in several places as high as 48 deg. from the horizontal. Along this pipe line, land slides had been frequent, and to obviate the danger from this source it was necessary to build just below the pipe line a number of rubble masonry retaining walls bedded on solid rock. Wherever slides appeared likely to take place the pipe was laid on the solid rock ledge which made it necessary frequently to excavate to great depths, in some cases as great as 30 ft.

It would have been somewhat cheaper in the long run to have located the pipe line in much nearer a straight line between Indian Creek dam and Connellsville, but a tunnel three miles long would have been required, and the great length of time necessary for this construction made that plan impracticable. From Connellsville northwardly the pipe line was laid principally along the right of way of the Pennsylvania R. R. At Radebaugh to keep below the hydraulic grade line, a tunnel about 2100 ft. long was constructed. This was circular in section, and lined with about 12 in. of concrete, and a 30-in. cast-iron pipe was laid in it. The pipe line in general was very troublesome and difficult to build in many cases on account of deep cuts, creek crossings, mine openings and difficulties in passing through towns. Very often where the railroad was in deep rock cuts there was hardly room on one side of the track for the pipe line trench, and the materials of excavation had to be removed and afterward brought back by work trains without interfering with traffic. Where streams draining mines had to be crossed the pipes were laid in and surrounded by concrete to prevent corrosion. Over the Monongahela River at Port Perry the 20-in. pipe line was laid on structural steel brackets bolted to the outside of the bridge structure. The pipe was made of steel with flanged joints, and afterwards covered with 3 in. of hair felt. Although the length of this bridge was over a thousand feet, no expansion joints were put in, but the stresses due to



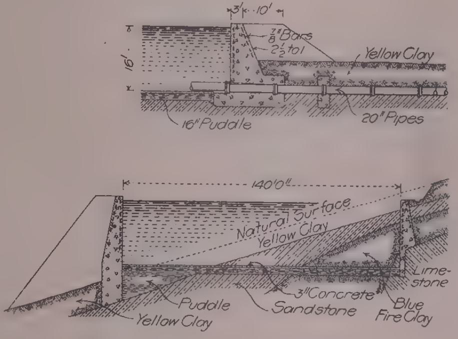
Dam of the Charleroi Reservoir.

temperature were amply taken care of by the tensile strength of the pipe itself and its joints, the maximum stress due to this cause not exceeding 20,000 lb. per square inch. At West Brownsville on the Monongahela Division the 12-in. pipe was laid below the bed of the river, the excavation being done by dredges, and the joints of the flexible type similar to the Ward joint were made by means of divers. The river was subject to sudden rises so that it required about eight months before this line could be built. During the construction one of these freshets caused the loss by sinking of a dredging outfit. The 20-in. pipe crossing under the Youghiogheny River between Connellsville and Wheeler was made in the ordinary manner by means of coffer dams, this plan being rendered possible by reason of the shallowness of the river.

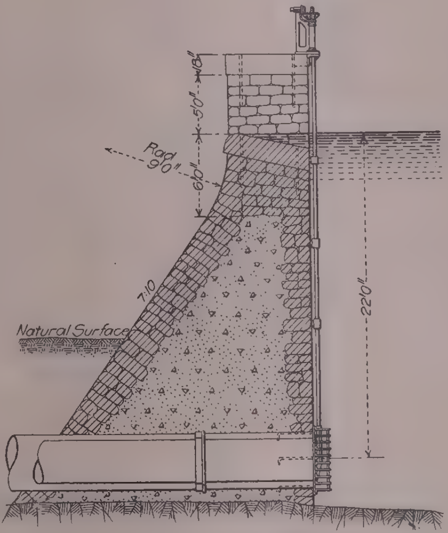
At the only available place where the Gibson Junction Reservoir could be constructed at a proper elevation, the material and foundations were found to be unsuitable for earth embankment construction, the ground was composed of shaley sandstone rock, and the surface sloped at a grade of about 10 per cent. The design adopted therefore consisted of a heavy rock excavation on the high side and sufficient at the low side of the reservoir to secure a satisfactory footing for concrete masonry walls. These were built of a top thickness of 3 ft. with vertical face against the water, and back slopes of 1 to 4. The material consisted of 1:3:5 Portland cement concrete. Reinforcing Johnson bars were used in the concrete to prevent as far as possible temperature cracks. On the high side of the slope the excavation was carried considerably wider than the neat line of the outside of the wall so as to allow of a pipe drainage system, and thus make it unnecessary for the wall to act as a dam in case the reservoir were emptied. The top portion of this wall was formed into a neat cement coping 8 in. thick and projecting 2 in. toward the reservoir. On the outside of the wall where it projected above the natural surface of the ground an embankment was formed, composed of the materials from the excavation. The top width was 10 ft., and the outer slope was 1½ to 1, the said slope and a portion of the top being sown with grass seed.

In order to prevent the possibility of damage to the upper 13 miles of 36-in. line due to water hammer, a 20-in. connection was made close to the Gibson Junction reservoir, and the 20-in. pipe was run up the side hill a distance of about 500 ft. to a small masonry chamber, and from this chamber a second 30-in. terra-cotta pipe was laid back so as to overflow into the reservoir at a point about a foot below the surface of the water. The elevation of the bottom of the 20-in. pipe was slightly higher than the flow line in Indian Creek reservoir. This device proved to be a not very expensive but effectual safeguard, and is always advisable where the natural conditions are so favorable as existed at this point.

With the exception of the Gibson Junction Reservoir above described, the distributing reservoirs are of two general types, one of which was used in the construction of Stoner's Summit, Radebaugh and Charleroi reservoirs, and the other in the construction of the Youngwood, Howard, Elben, Smock and Gist reservoirs. In the first type the reservoir is formed by an earthen dam having a top width of 12 ft. and outer and inner slopes 1½ to 1. At the foot of the upstream slope is sunk a puddle trench 6 ft. wide and down to impervious material. The upstream portion of this puddle trench is filled with 2 ft. of concrete, and the downstream 4 ft. with compacted clay laid in thin layers, and at the surface incorporated with the rolled embankment. The concrete is then connected with the slope concrete which is 12 in. in normal thickness, and laid to within 3 ft. of the flow line. From this point to 2 ft. above the flow line is laid a masonry slope wall 18 in. in thickness. The best material was selected from the excavation for the upstream portion of the embankment, and the whole was compacted in layers less than 6 in. in thickness by means of heavy grooved rollers run by steam. It would seem that this type of construction whereby a water-tight masonry curtain covers the entire upstream slope of the embankment and extends down to impervious material has decided advantages over the old-fashioned method of constructing a core wall at the center of the embankment.



Gibson Junction Reservoir.



Indian Creek Dam.

The other type of reservoir is formed of an earthen embankment lined on the water side with 12 in. of concrete, and the outer slopes are either sodded or seeded. The bottom of the reservoir is covered with 16 in. of compacted clay laid in thin layers and covered with 3 in. of concrete connected with the slope concrete. The flow line in both cases is kept at least three feet below the top of the embankment.

In order to maintain the reservoirs full of water and prevent overflow, automatic controlling valves are provided on the inlet mains. There is also provided on each reservoir outlet main a large screen pot, the screens of which are made of ¼-in. mesh wire.

The gate houses are all built of the same general type. The walls are of broken range masonry having 12-in. and 6-in. rock-face stones laid with vertical and horizontal joints and regular alternate pattern. The roofs are of red tile and the floors are all concrete on steel I-beam construction.

Near the points of consumption on the distributing system of pipes large relief valves are provided with either 6 or 8 in. opening, and in many cases the railroad water tanks are provided with relief valves on the supply pipe within the tank.

At several points along the supply mains are provided meters of the Venturi principle, and by this means a close count is kept of the water furnished to every portion of the system. Each meter is provided with a rate of flow dial and a six figure register dial, and they are read once per week and observed whenever advisable to determine the rate of flow at particular times. Their value in the operation of pipe lines is incalculable and they should never be omitted from a gravity system of a character similar to this one.

The total length of pipe on this system is as follows: 36 in., 17.06 miles; 30 in., 32.17 miles; 24 in., 3.29 miles; 20 in., 7.74 miles; 16 in. 4.42 miles; 12 in., 66.30 miles; 10 in., 4.27 miles; total, 135.25 miles.

The reservoirs and their capacity are summarized as follows: Indian Creek reservoir, 231,000,000 gal.; Gibson Junction reservoir, 6,500,000 gal.; Stoner's Summit reservoir, 13,670,000 gal.; Youngwood reservoir, 1,000,000 gal.; Radebaugh reservoir, 8,500,000 gal.; Pitcairn reservoir, 1,760,000 gal.; Howard reservoir, 2,000,000 gal.; Elben reservoir, 2,000,000 gal.; Charleroi reservoir, 7,235,000 gal.; Smock reservoir, 2,000,000 gal.; Rainey reservoir, 2,000,000 gal.; Gist reservoir, 2,800,000 gal.; total, 280,465,000 gal.

The entire work above described was constructed by the American Pipe Mfg. Co., according to its reports, plans and engineering supervision, all matters appertaining to the Pennsylvania Railroad Co. being subject to the revision and approval of Mr. Joseph T. Richards, chief engineer of maintenance of way.

A New Filter Bed Regulator.

A new filter bed regulator for automatically controlling the flow through sand filters is now being used at a number of places on the Continent. The apparatus is placed in a chamber connected with the supply chamber of the under-drain system by a pipe closed with a balanced inlet valve opening downward. Connected with this valve and immediately above it is a float which carries a siphon pipe straddling a partition which divides the regulator chamber into two parts. One side of this partition houses the float and the balanced inlet valve, while the other side is connected directly to the supply mains. When the rate of flow through the filter bed decreases owing to the increasing resistance of the gelatinous surface layer, the flow of water through the balanced inlet valve also decreases, the water level in the siphon chamber falls, and the float dropping to a lower level, increases the opening of the inlet valve into the siphon chamber and consequently allows of a greater flow. This increase is due to the fact that more water is discharged through the inlet valve from the supply chamber of the under-drain system, which accordingly has its water level lowered, thereby increasing the head on the filter bed. The action evidently is automatic, since it depends entirely on the water level in the siphon chamber, which responds to the rate of flow. Suitable auxiliary attachments are provided for maintaining the water seal of the siphon and balancing the weight of the floating parts. The apparatus is called the Didelon regulator and was described in a recent issue of "Engineering," London, from which these notes were taken.

Briquettes were used for fuel to the extent of 44,000 tons by the Austrian State Railroads last year, according to a consular report. About one-fourth of these came from England and cost about $5.80 per ton, and the remainder from Pilsen, Bohemia, at $3.60 per ton. Some of the briquettes weighed 2.2 lb. and the others 4.4 lb. each.

APPENDIX 12, REPORT OF QUEBEC BRIDGE COMMISSION.

A Description of the Fallen Structure.

The Commission began its inquiry by examining a number of workmen who were understood to have seen the disaster.

A study of this portion of the evidence brings out clearly one or two main facts but with an almost complete absence of important detail. This is not surprising when the suddenness with which the disaster came and the few seconds occupied by the downfall are considered. The evidence of Huot, who ran from the second panel of the anchor arm to the office at his topmost speed, enables us to fix the duration of the fall at not above 15 seconds. The distance is almost 100 yd., and the floor was already opening between the end of the anchor arm and the approach span as he passed that point. It is not surprising that accurate evidence was not obtainable, as every man's first thought was of self-preservation, and there was no time to consider or realize what was happening.

The records of the inspectors, which show the deformations that were taking place during the month preceding the accident, are corroborated by the witnesses D. B. Haley and Alexandre Beauvais, the latter in particular testifying to the "working" of the ribs both at joint A9-10R and at joint A9-10L. It should be noted that neither of these joints gave way at the time of the accident and that injuries that they had received are due to the fall itself.

The collapse came very suddenly. The witnesses who were on the bridge outside of the main pier, Haley, Nance, Hall, Davis and Laberge, all testify that they had no warning of any kind, and several of the men who were working on the ground directly under the anchor arm, were caught by the falling structure and killed, when by moving not more than 50 ft. they would have saved themselves.

The cantilever arm and suspended span fell as a whole. The witnesses Wickizer and Esmond, both of whom were in good position for observation, testify to the whole cantilever arm falling as one piece and the former adds that the outer end of the cantilever arm swung slightly to the east, so that he could see directly between the trusses from his position on the jetty on the north shore.

The big traveler fell as if it was part of the cantilever arm, and did not upset, at least until after the arm had struck the water. The accident was immediately followed by the rising of a cloud of dust and spray that obscured everything and there is no evidence concerning the final movement of the traveler; the witnesses Hall and Laberge testify that it did not upset, to their knowledge. The tops of the center posts moved slowly riverwards and dropped suddenly, when the center-post feet kicked off the pedestals on the main pier; the post feet were forced southwards. The witness Chase states that he saw these movements.

The anchor arm broke near the center, and in its first movement appeared to rise in the neighborhood of the break, and then fall; the witness Culbert states that he observed this.

James Johnson testified that he thought the lower chord of the anchor arm near the third panel from the main pier struck the ground first; and Delphis Lajeunesse, clinging to the west truss of the anchor arm as it fell, noticed that the trusses appeared to be toppling over towards the east.

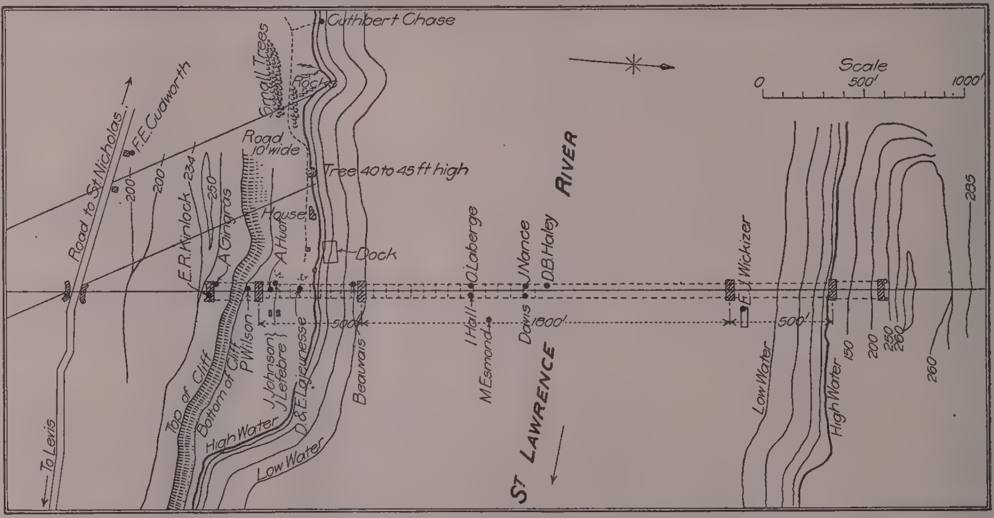
The anchor arm fell almost without movement to the right or to the left. Mr. Kinloch noted that the portal posts sank down and, using his own simile "as if they were ice pillars whose ends were rapidly melting away." In other words, as he stood near the center line of the track and opposite the office, the end posts while falling straight away from him, appeared to only settle down.

Mr. Cudsworth's evidence indicates that the trusses first toppled slightly to the east, he being able to see only the top portions of the center posts and the adjoining members, then followed an outward movement similar to that described by the witness Chase, and finally everything disappeared suddenly from sight.

Out of 86 men on the work only 11 escaped with their lives.

The Commission commenced its examination of the wreck by instructing the inspectors and engineers of the Phœnix Bridge Co. and of the Quebec Bridge Co. to go over the débris of the anchor arm and to paint in large letters on each main member its erection mark.

The wrecked structure in places was in so chaotic a condition that even these men, who had been familiar with the appearance of every piece of the anchor arm for nearly two years, had difficulty in identifying many of the members.



Drawing 10, Report of Quebec Bridge Commission. Plan Showing Positions of Witnesses.

The photographs, 24 in all [not reproduced] were taken as soon as the marking was completed.

Surveys of the wreckage and adjoining ground were arranged for, the results of these surveys being shown on the following drawings:

Drawing 10: Positions occupied by witnesses at the time of the fall.

Drawing 14: Check measurements to determine the position of the main pier. [Not reproduced.]

Drawing 15: Positions occupied by camera when the photographs in Exhibit 34 were taken. [Not reproduced.]

Drawing 16: Diagram of fall of east truss.

Drawing 17: Diagram of fall of west truss.

Drawing 18: Diagram of fall of floor beams and stringers. [Not reproduced.]

Drawing 19: Diagram showing the shape of chords A9-L and A9-R after the accident.

Mr. Walter J. Francis, M. Can. Soc. C.E., was requested to make an examination of the wreckage and to prepare such descriptions and photographs of selected bridge details as would be of service in assisting the work of the Commission.

A number of photographs from Mr. Kinloch's collection show clearly the details of several intricate intersection points, and give an excellent idea of the demands that this bridge made upon the technical skill of the designing officers and upon the resources of the manufacturers. It should be remembered that the component parts of the structure were never put together until finally erected; every detail was planned by the designers and made without trial or fitting, prior to erection in place.

The measurements to the piers showed that the masonry of the main pier had risen very slightly when relieved of the load of the superstructure, otherwise it had remained exactly in its original position. The results of these surveys were accepted as proof that there were no defects in the substructure or foundations to contribute to the disaster.

The plans of the wreckage show:

(1) That there was practically no lateral movement of the anchor arm lower chords and floor system while falling. This we regard as a proof of simultaneous failure in the two trusses.

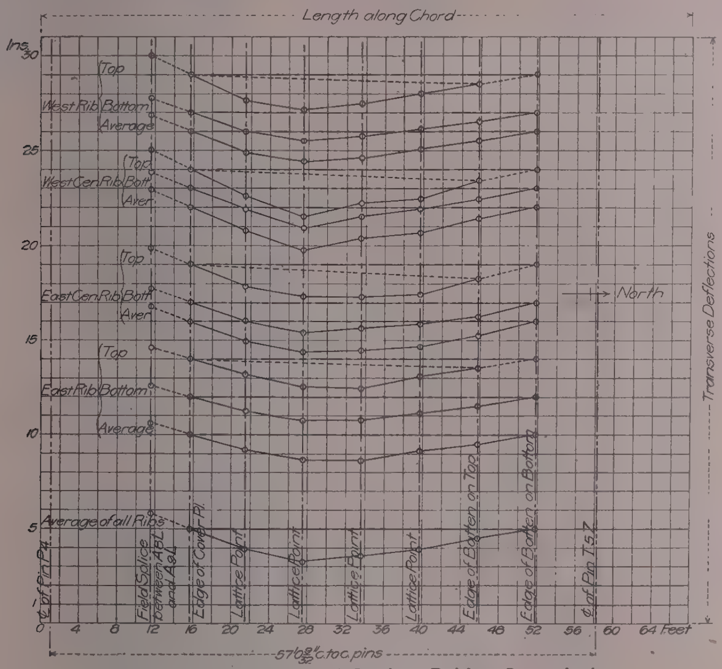
(2) That there were opposite longitudinal movements of those lower chords and part of floor system that were to the north and south respectively of the joint 8-9 anchor arm. This is proof that the initial failure took place close to this joint.

(3) That there was an almost complete destruction of the chords 9A-L and 9A-R, that of 9A-R being the more striking and peculiar.

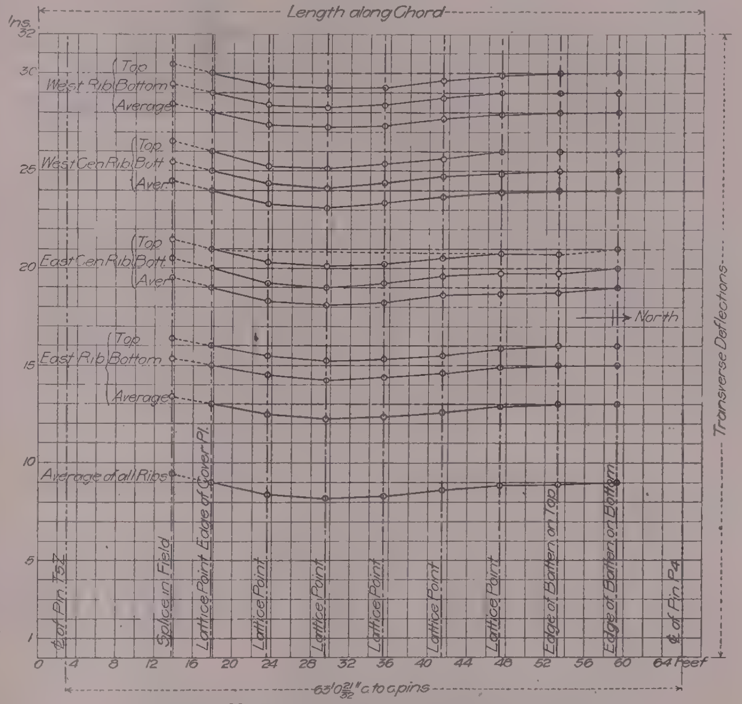
We cannot describe the failure better than by quoting the evidence of Mr. Kinloch, whose knowledge of the structure both before and after its fall is exceptional.

"Q. Please describe the movements that you think took place when the bridge was falling.

"A. The initial failure, I think, occurred in both lower chords No. 9 anchor arm simultaneously and in the latticed portion of the chords, but not in the same way in both chords. No. 9-L, which had previously been observed to be bent, deflected slowly and transferred some of its load to 9-R until that chord burst with a sudden fracture accompanied by the loud report testified to by some witnesses. The sudden and complete collapse of 9-R while 9-L was slowly yielding accounts for the slight swing of the cantilever arm downstream and for the tendency of the upper portions of the anchor arm to fall in the same direction. At the moment of collapse the thrust of the cantilever arm forced the feet of the main posts off the pedestals and the shoes of the main posts were the first part of the structure to strike the ground. While they were in the air the extremities of the stub chord on the cantilever arm struck the inside coping of the main pier a glancing blow. When the shoes struck the ground that part of the C. P. 6 above the batten plates failed and simultaneously the horizontal strut connecting the two shoes was destroyed. The transverse diagonal bracing between the two posts at the bottom remained intact for an instant and almost the entire weight of the main post and of the top chord was concentrated upon it, causing the bracing to act as a toggle and to force the shoes and the feet of the main post out sideways. This is shown by the holes made in the ground. This action threw the bottom portions of the center post out of the vertical and permitted the feet of the P-4 posts with the broken ends of A-8 attached to them to pass inside the center posts, some part of P-4-L striking C. P. 6-L heavily as it fell. During the fall the chords 10-R and L cantilever arm, which had probably broken loose when the stub chords struck the pier, rested for a moment on top of the pedestals and were then partially up-ended and thrown over on their sides, as they now lie on top of the pier, by the wreckage of S. P. 5 and of the pieces connected to it. Chords 9 of the cantilever arm did not strike the pier before they reached the ground, although they now lie with their ends just against the face of the masonry, which is slightly marked. Chord 9-R of the cantilever arm is lying in the water with its two inner ribs practically straight and its two outer ribs buckled back in a V-shaped loop about 18 or 20 in. long at a point about 20 ft. from the shop splice, the ends being parallel to the inner ribs. Chord 9-L is buckled at about 15 ft. from the field splice in all four ribs to a shape similar to that shown by A-1-R, but with a smaller deflection."



Drawing 28, Report of Quebec Bridge Commission. Deflection in Lower Chord A9L, Anchor Arm, Aug. 27.



Drawing 29, Report of Quebec Bridge Commission. Deflection in Lower Chord 9R, Cantilever Arm, Aug. 27.

The warnings of coming disaster are thus referred to by Mr. David Reeves: "When the compression members began to yield at several places one after another, as we can now see, and the whole bridge was at the verge of collapse, as afterward developed, etc., etc." This statement calls for comment.

We do not consider that any of the difficulties with lower chord members noted previous to Aug. 1, 1907, were of serious moment with the possible exception of the fall of chord A-9-L in the storage yard, the effect of that fall upon the latticing of the member was not determined, and, in fact, was practically impossible of determination.

Our investigations at Belair yard have convinced us that the several discrepancies noted in the chords during the earlier stages of erection were probably due to errors of shop-work, and, as Mr. Cooper said, were not serious. The waviness of the ribs which was often recorded by the inspectors might not produce serious results, its importance being dependent upon the strength of the latticing. (See Appendix 11, Eng. Record, March 14.) The presence of these bends would materially increase the stresses in the latticing, but we have no evidence to show that there was exceptional waviness in the chords that afterward deflected most seriously.

The erection of the suspended span did not begin until the middle of July, 1907, and the building out of this span was accompanied by a rapid increase of the stresses in the anchor and cantilever arms. On the day of the disaster the most heavily stressed members were as follows:

Member.	Panel.	Arm.	Stress, per sq. in.
Upper Chord........	7	Anchor	17,200 lb.
“ “	8	“	17,230 “
“ “	9	“	18,200 “
“ “	10	“	18,200 “
“ “	7	Cantilever	18,850 “
“ “	8	“	18,920 “
“ “	9	“	18,110 “
“ “	10	“	18,100 “
Lower Chord........	5	Anchor	17,010 “
“ “	6	“	17,100 “
“ “	7	“	18,040 “
“ “	8	“	17,830 “
“ “	9	“	17,910 “
“ “	10	“	17,560 “
Lower Chord........	7	Cantilever	17,730 lb.
“ “	8	“	17,430 “
“ “	9	“	17,880 “
“ “	10	“	17,080 “
Main Diagonal......	5	Anchor	17,080 “
“ “	4	“	17,160 “

By the beginning of August the effect of these growing stresses on the weak end details of the chords became perceptible, and by the middle of August the chords began to show signs of failure in the body. On Aug. 6 the deflection of joint 7-8-L cantilever arm was noted, and Mr. Kinloch has expressed his conviction that this deflection occurred after the lower cover plate was removed. The design of the chord ends and joints was such that it is probable that Mr. Kinloch's conclusion is correct, and that the removal of the lower cover plate weakened the joint appreciably. Any distortion at the joint would throw considerable stresses into the latticing unless the batten plates were of great strength and stiffness. On Aug. 12 the inspectors reported a similar deflection at joint 8-9-L cantilever arm. On Aug. 8 the workman, Haley, noticed that the ribs at joint 8-9-R, cantilever arm, did not match properly, and on Aug. 28 he noticed that the splice plates were bulging. This was noticed by Mr. Kinloch also, who was confident that they were all right when riveted. Haley also saw the chord 8-R, cantilever arm, close to the joint just mentioned, was bending in all its ribs. The workman, Beauvais, noticed, during the two weeks previous to the accident, that the inner ribs at the joint 9-10-R anchor arm were gradually coming together, but does not seem to have reported this. About Aug. 20 Mr. Kinloch noticed that chords 8, 9 and 10 R cantilever arm, were wavy in the body, but was not sure whether the bends were shop bends or not; he consulted Mr. Birks and they agreed that these waves were of no importance. On Aug. 25 the deflection at joint 5-6R caltilever arm was discovered. On Aug. 27 the bending in chords 9-L, anchor arm, and chords 8 and 9 R cantilever arm, had become so noticeable that they were measured in detail, and reported to both headquarters. Mr. McLure's records note a deflection of ¾ in. in chord A-9-L about one week previous to Aug. 27. This recital shows that the chords near the main pier both in the anchor arm and in the cantilever arm were under close observation for at least a week previous to the accident. These were the most heavily stressed compression members in the bridge.

We are satisfied that the structure was being closely watched and that had there been noticeable weakness at any points it would have been detected and recorded. There is no evidence of the existence of weak details except on the lower chord.

We therefore conclude both from the evidence of the witnesses, and from that of the wreckage, that the initial failure occurred in chords 9-R and 9-L, anchor arm.

Our opinion is that these two chords failed almost simultaneously by rupture of latticing or shearing of lattice rivets, and that the buckling of the ribs followed immediately. The cantilever arm commenced to drop, turning around the feet of the center posts, and raising the anchor arm near the point of rupture. When the top of the center post had leaned over perhaps 30 ft. (this estimate being made by the witness Chase) the center post feet kicked off the pedestals, and both anchor and cantilever arms crashed down. The right truss of the anchor arm apparently fell faster than the left truss, for the top members of the arm have fallen towards the right, and the witness Delphis Lajeunesse noticed such a movement. The stub chords on the cantilever side which were attached to the center post feet struck the coping of the masonry heavily, the marks of the contact on these chords indicating that the right post was falling the faster. The cantilever arm was controlled in its fall by the stiffness of the center post, and by the resistance of the upper chord, and did not drop suddenly until the feet of the center posts kicked off the pier. The center post feet reached the ground first; carrying inwards before them the lower parts of panels 9 and 10 anchor arm; the remainder of the anchor arm was swung forward by the action of the upper chord in straightening out, under the pull of the cantilever arm, and moved around the top of the anchor pier as a fixed point. The damage to the lower chords from the fall was the more severe because the ends of the posts landed in the foundation pits dug for the falsework, and the chords themselves struck on the high ground between the pits. The forces that pushed the center post feet out into their present position, as described by Mr. Kinloch, are a matter of conjecture; the holes dug by the feet in their fall are plain to view and are partly filled by sections 5 of the center posts which are standing upright in them. As these sections are comparatively little injured and have not dug down into the ground, it is evident that they struck with but little force and that the ground was already shaped to receive them. The force of the fall was probably largely absorbed in the wrecking of sections 6 of the center posts.

No description in words can give as correct an idea of the wreckage as will be obtained by a study of the photographs, [The Engineering Record has been unable to secure the official photographs, but others were printed in its issue of Sept. 14, 1907]; the principal feature to be noted is the comparatively uninjured condition of all members except some of the lower chords, posts and sub-posts which by reason of their position had to bear the larger portion of the forces developed by the fall, and completely failed under them.

All connections except the splices of the lower chords proved to be as strong and in most cases much stronger than the body of some of the members they connected. The tension members, laterals and floor system call for little comment; the compression members and their splices have shown themselves to be the weakest parts of the structure.

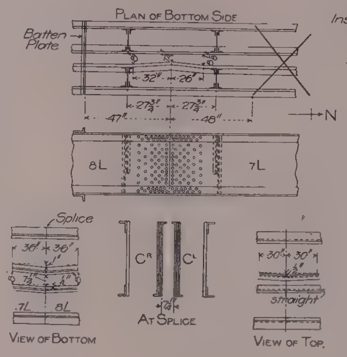
The following is a statement of Mr. Walter J. Francis' observation of the wrecked structure, and which clearly describes certain phases of it:

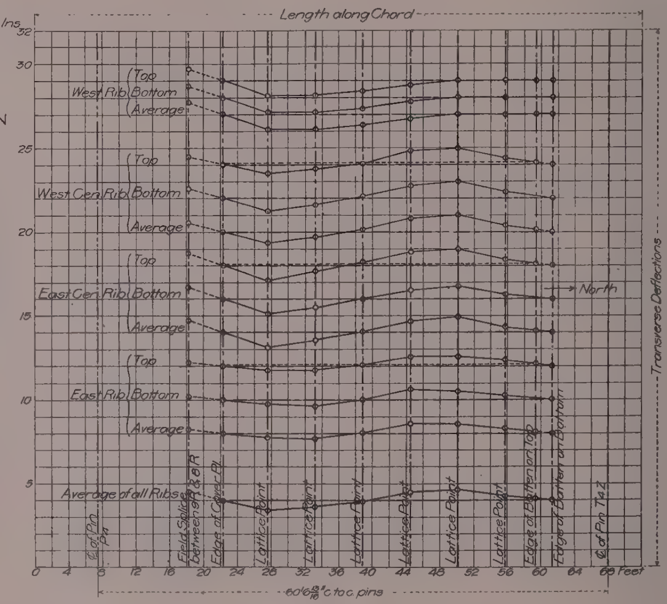
"The condition of the posts throughout may be said to be largely the result of the unyielding strength of the top chord eyebar system, while the condition of the other members may be regarded as due to their fall to the earth and upon one another.

"Of more than 700 eyebars in the wreck, only one has been found which has broken, and on all remaining ones there is not a sign of a crack or failure of any kind, notwithstanding the extreme punishment to which these members have been subjected. The broken bar, 1 1/16 x 15 in., is undoubtedly the result of a heavy blow on the edge about 18 in. from the center of the pin. The bar parted about 4 ft. from the center of the pin, in acting as a beam. The fracture is fine-grained, and although not of the highest class it would certainly be rated as good.

"Of about 60 pins in the accessible parts of the débris only one has any evidence of having been distorted. This pin is 12 in. in diameter, 8ft. 6in. long, bored 2⅞ in. diameter through its axis lengthwise. Its bend consists in having one end turned up about 5 in., the curve being about 1½ ft. from this end. As this pin is at the joint where the eyebar above referred to was broken, its condition is undoubtedly due to the same cause as that which broke the eyebar.

"Speaking generally, the compression members throughout have suffered severely. They were generally composed of parallel laminated webs. In the maximum size of chords there were four vertical webs. Each web consists of four plates ranging from 13/16 to 15/16 in. in thickness, and one angle on each edge 8 x 6 x 15/16 in. for outside webs, or 8 x 3½ x 15/16 in. for inside webs, the 8-in. leg being vertical. The finished width back to back of angles was 54 in. The maximum length of these webs was about 57 ft. At each end the four webs are connected together top and bottom by cover plates varying from 6 to 10 ft. long, the space between the cover plates being latticed with 4 x 3 x ⅜-in. angles. The tower posts had four parallel webs, while in other posts there were two webs only, latticed for the greater part of their length with 3 x 3 x ⅜-in. angles, set at about 60 deg. Speaking generally, at and near the panel points of all these members, there were either internal diaphragms, or cover-plates, or both. Throughout the middle length of the members there were none. In the wreck the compression members are distorted in every conceivable manner, excepting at the panel points, where the portions having internal diaphragms or outside covers are yet comparatively straight after enduring the forces of the fall. Between these stiffened portions the lattice work is torn, the laminated webs are parted, and the rivets sheared and pulled in every possible way.





Drawing 30, Report of Quebec Bridge Commission. Deflections in Lower Chord 8R, Cantilever Arm, Aug. 27.

"The component parts of the various built-up members have been destroyed by all sorts of complications.

"The evidence of heat produced by blows and friction is in many instances quite marked; one case was noted where the steel had been fused and drawn into shreds and small globules.

"Although quite secondary to the main members of the bridge, it is interesting to note that the 1⅝-in. anchor bolts holding the vertical steel in position on the anchor pier drew bodily out of the masonry. These bolts had the ordinary surface of a steel rod, were swedged on the opposite sides every 3 in. and were 4 ft. 6 in. long. The holes in which they were set were drilled in the granite masonry just large enough to admit the bolt. They are said to have been grouted in with pure Portland cement. In every case where they received direct tension they pulled bodily out of the masonry.

"It is almost beyond comprehension that both the main pier and anchor pier should have withstood the shocks of the accident. There is no indication of any movement in, or general damage to, either of these piers. The arrises have been abraded in some cases, and where the main shoes left the pedestals the blow they administered to the coping and cornice molding spawled the granite in one case for about 22 ft. in length. The effect on the masonry, however, can only be absolutely determined by an exhaustive examination."

As the lower chords call for particular attention we give here a memorandum of the condition of these chords after the accident. The other portions of the structure are sufficiently illustrated in the photographs and drawings already referred to. This memorandum was prepared by Messrs. Cudworth, Kinloch and McLure, and was checked by the commissioners and found to be a correct description. It is as follows:

A-1-L.—Starting with its pin connection with anchorage eyebars, 79 ft. from center line of anchor pier and about 35 ft. above the ground. A-1-L slopes at an angle of about 70 deg. to the horizontal, until it rests on the ground at a point 90 ft. from the center line of anchor pier. Here the four ribs are broken entirely off, the west rib 3 ft. north of its splice to chord A-2-L, the west and east center ribs at the field splice to A-2-L, and the east rib through the web at south ends of splice plates. The top cover plate is still attached to A-2-L, and the bottom cover plate is torn off entirely. The latticing is still practically intact.

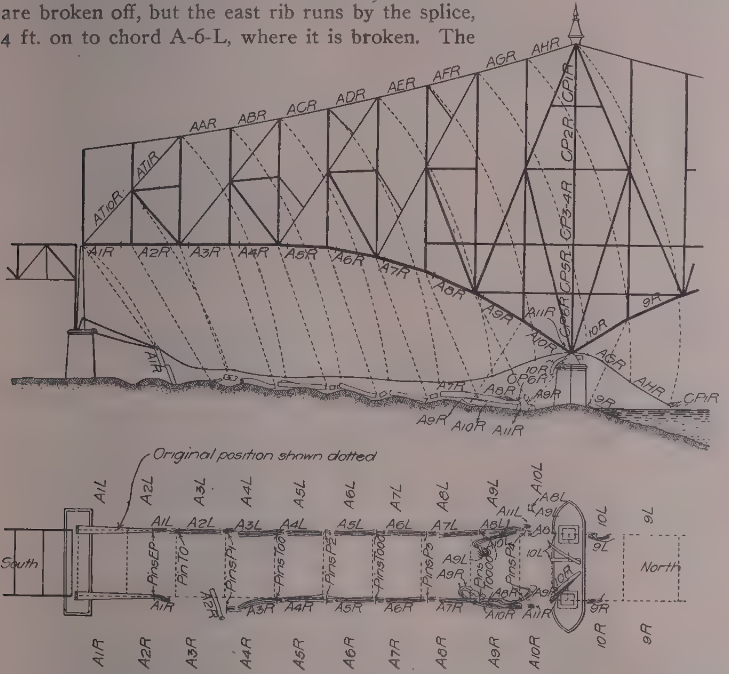
A-2-L.—The portion of A-2-L separated from A-1-L as above described, lies on the ground 96 ft. from center line of anchor pier, the break being about 6 ft. south of pinhole connecting hanger T-0-L. The chord bends to the east from this point to a point 118 ft. from center line of anchor pier, where all four ribs are twisted and broken through the angles and web plates from the tops, half way down. At this point of break the deflection from a straight line is the maximum and about 6 ft. From this break the chord dips downward at an angle of about 10 deg. with the horizontal and slightly westward. The pin hole for connection of A-P-1-L is intact and all four ribs of this chord are broken off at the field splice 8 ft. north of this pin hole. The top and bottom cover plates at the splice with A-3-L are torn from A-2 and fast on A-3. The latticing at point of break is broken and all the remaining latticing badly bent up, but in position.

A-3-L.—Starting with its splice with A-2-L, recorded above as broken, A-3-L has its four ribs in a straight line about parallel to axis of bridge, to a point 170 ft. from center line of anchor pier, where the west rib is bent in toward the center of chord, and the latticing broken, but rib itself uninjured.

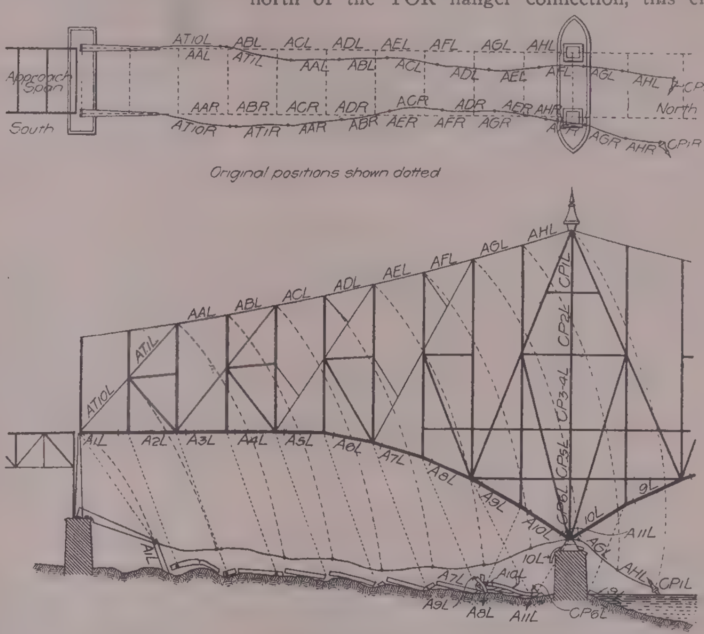
The pin hole for connection of TOO hanger is intact, but all four ribs are broken through at the field splice 8 ft. north of this pin, right through the splice plates to A-4-L. At this point the south end of A-4-L lies 4 ft. above the north end of A-3-L and 3 ft. to the west. At this splice between A-3-L and A-4-L, the bottom cover plate is torn from A-4-L and fast to A-3-L, and the top cover plate is torn from A-3-L and fast to A-4-L.

A-4-L.—The four ribs of A-4-L run parallel to each other from their splice with A-3-L to a point 10 ft. south of pin connecting post P-2-L, at which point the east rib spreads a foot toward the east till it reaches the pin hole of P-2-L post. At this point all four ribs are broken through. North of this pin hole the two outer ribs are spread, but converge to their splice with A-5-L at which point the two center ribs are broken off entirely, but the outside ribs intact.

A-5-L.—A-5-L runs continuously from its field splice with A-4-L to pin hole for connection of TOOL hanger, where all four ribs are broken through. From this pin hole the chord runs straight to field splice. Here the three west ribs are broken off, but the east rib runs by the splice, 4 ft. on to chord A-6-L, where it is broken. The top cover plate at this splice is fastened at its east edge only, and the bottom cover plate torn loose from A-6-L and fast to A-5-L. The latticing has been little damaged.



Drawing 16, Report of Royal Commission on Quebec Bridge Failure. Positions of Panel Points of East Truss before and after Accident.



Drawing 17, Report of Royal Commission on Quebec Bridge Failure. Positions of Panel Points of West Truss before and after Accident.

A-6-L.—A-6-L at its splice with A-5-L is offset about 2 ft. toward the west and from there runs in a straight line to the pin hole for connection of P-3-L. Here all four ribs are broken through. Beyond the pin hole the east rib is displaced slightly to the east to the field splice with A-7-L. At this splice the top cover plate is fast to east rib of A-6-L only and bottom cover plate fast to four ribs of A-6-L only. The latticing is little damaged.

A-7-L.—From its splice with A-6-L, A-7-L is deflected slightly to the west until it reaches the pin hole for connection of TOOOOL hanger, where all four ribs are broken through. From this pin hole to the field splice with A-8-L the ribs run straight. At the splice the two center ribs are broken through the splice plates, but the outside ribs are intact. The latticing is little damaged.

A-8-L.—The ribs of A-8-L run straight from its splice with A-7-L for a distance of about 20 ft. At this point the west rib bends to the west about 90 deg. and rises in the air to a height of about 20 ft. The west and east center ribs start to bend at the same point, but come back again, forming a reverse curve and burying themselves in a pile of scrap iron immediately beyond the pin hole for the connection for P-4-L. The east rib follows the same general direction, but its north end instead of turning downward, makes a hook toward the east. All four ribs are broken off at the pin hole for P-4-L, the piece from the west rib lying out on the beach about 25 ft. from the present position of the west main pier shoe, and having attached to it 2 ft. of the west rib of chord A-9-L, with the field splice intact. The latticing is almost entirely destroyed.

A-9-L.—Beginning at the field splice with chord A-10-L, at which splice all four ribs are broken, the west rib of A-9-L runs south, at an angle of 45 deg. to the axis of the bridge toward the east to the pin hole for the connection of A-T-5-Z hanger, at which point it starts to bend eastward, turning through about 180 deg. in a length of 15 ft. and thence running north 8 ft. At this point it bends through 180 deg. again in a length of 10 ft., and then runs south and inclined upward at an angle of 40 deg. with the horizontal, to a point 2 ft. beyond its field splice with A-8-L, which splice is intact and fully riveted. At the last bend mentioned three of the web plates are broken through.

Running parallel to west rib to T-5-Z pin hole, the west center rib is there broken but continues beyond, turning through 180 deg., and running north for 8 ft., then bending back 180 deg., at which bend two of the web plates are broken through, and running south to its former field splice with A-8-L where it is broken.

The east center rib runs parallel to west center, but is not broken at pin hole, and at the last bend has only one web plate broken.

The east rib parallels the east center rib through the first bend of 180 deg. to a point 8 ft. north of the pin hole, where it doubles over on itself and projects upward and toward the west to a height of 14 ft. above the ground.

The distance from the field splice with A-8-L to the chain mark on west center rib is 13 ft. The center of maximum bend of the chord is about 20 in. forward of this point, and the loose rivet discovered in the lattice angle is about midway between the chain mark and the center of the bend. This bend lies about 15 ft. south of the fracture in the floorbeam between P-4 posts. All of the west end of A-9-L is still attached to T-5-Z hanger, and all of its four ribs are bent through 180 deg. at a distance of about 8 ft. from the T-5-Z-L pin hole.

At the second bend mentioned in the east rib, two web plates are broken through. The lattice angles are completely destroyed.

A-10-L.—The four ribs of A-10-L, starting from its field splice with A-9-L, at which all four ribs are broken, runs in a straight line slightly inclined westward, with the ribs folded over and lying one on top of the other, the latticing being completely destroyed.

A-1-R.—Starting with its connection with the anchorage eyebars, A-1-R dips downward at an angle of about 70 deg. to the horizontal. At a point 6 ft. distant horizontally from the south end it is crippled through all four ribs, and bends toward the east, the flange angles being cracked through here and the latticing torn off. Turning again 90 deg. it runs straight down into the ground at the pin hole for the connection of TOR hanger, at a very short distance beyond which, buried in the mud, the four ribs are broken off through the webs. The field splice 4 ft. south of ATOR hanger pin hole is intact on the two outer ribs, but slightly loosened up on the inner. The top cover plate is on, but the bottom one partly torn off.

A-2-R.—Beginning at the break mentioned as north of the TOR hanger connection, this end of A-2-R has been thrown westward to a position 138 ft. from center line of anchor pier and 5 ft. west of original east truss line, the chord turned up on its west side, and running northeast to a point 155 ft. from center line of anchor pier and 31 ft. east of original line of east truss. The chord has a long bend at its center, and the latticing is badly bent up, but for the most part still fast to the chord. All four ribs are broken completely through just south of the P-1-R pin hole, and form the end last located. The remainder of the chord lies at the foot of P-1-R post and runs north from that to its field splice with A-3-R at which the east rib is broken 3 ft. north of splice on chord A-3-R, and the other ribs broken right at the splice.

A-3-R.—At a point 6 ft. from its field splice with A-2-R this chord bends sharply to the east for 5 ft., and then back again to a direction about parallel to axis of bridge. At the pin hole for connection of ATOOR hanger, the east rib only is broken. At the field splice with A-4-R the east rib is intact, and the other three ribs broken through. The bottom cover plate is fast to east rib of both chords, and top cover plate to all ribs of A-4-R and to east rib of A-3-R. The latticing is in good condition at south end, and broken off at north end.

A-4-R.—From its field splice with A-3-R, A-4-R runs straight to a point 10 ft. south of pin hole for connection of P-2-R post, where the outside ribs bulge out around the pin hole to the field splice with A-5-R. At the pin hole all four ribs are broken through. At the splice the west rib is partly, and the other three entirely broken through. The batten plate on chord just south of P-2-R is entirely destroyed. The latticing is little damaged.

A-5-R.—Runs straight from its field splice at south end to the pin hole for connection of TOOOR hanger, where all ribs are broken through. From the pin hole to field splice at north end the chord is tipped up in the air at an angle of 45 deg. to the horizontal. At the field splice the splice plates are stripped off the two outside ribs. On the inner ribs the splice plates are broken through. Latticing partly broken.

A-6-R.—Runs straight from its field splice with A-5-R to pin hole for connection of P-3-R post, where the four ribs are broken through. From the pin hole to its field splice with A-7-R, chord inclines slightly west. At this splice all four ribs are broken, and the short section thus left is tipped up about 15 deg. with the horizontal. The latticing has been little damaged.

A-7-R.—Starting at an offset of 18 in. east from A-6-R at splice, A-7-R runs straight to pin hole for connection of ATOOOOR hanger, where the four ribs are broken through at pin hole. From this point, to field splice with A-8-R, the chord inclines slightly westward. At the latter splice everything is intact except the bottom cover plate, which is partly broken off from east rib, latticing bent up, but not badly broken.

A-8-R.—Running 6 ft. north from its field splice with A-7-R the chord is straight. At this point the three west ribs take a sharp bend through almost 90 deg. to the east for 6 ft., followed a little further north by a similar but wider bend in east rib, all four ribs turning north again to meet the pin hole for connection of A-P-4-R post, at which point the ribs are all broken off.

The west rib runs from this pin hole to splice which is intact, and continuing on to the west rib of A-9-R makes a sharp bend of 180 deg. to the west and south, and in a few feet, again turns about 75 deg. to the west and is broken off through its web about opposite the pin in foot of A-P-4-R.

The west center rib parallels the west rib, across the field splice, continuing on to the same rib in chord A-9-R and terminating in a broken end at about the same point as the west rib.

The east center rib runs from the pin hole to the field splice, and is there broken off.

The east rib runs from the pin hole across the splice, which is intact, on to the same rib of chord A-9-R, turning to the east and south through about 150 deg., and terminating in a broken end at a point about 2 ft. north of the pin at foot of post A-P-4-R.

A-9-R.—Starting at the field splice with A-10-R this chord runs south, almost directly underneath chord A-7-R, to the pin hole for connection of A-T-5-Z hanger, at which point all four ribs are broken. From here the four ribs turn to the west about 90 deg. and run completely under A-7-R. After passing under the latter chord the east rib continues almost directly westward for a distance of 20 ft. and terminates in a broken and twisted end, which probably matches the other end of this rib described under chord A-8-R and located about 75 ft. distant.

After emerging from underneath chord A-7-R the other three ribs continue the 90 deg. bend to one of about 180 deg. and run directly north, the east and east center ribs terminating in ends broken and twisted directly opposite and just west of field splice between A-9-R and A-10-R and the west center rib continuing its course north to its faced end, opposite and directly east of field splice between A-7-R and A-8-R, and before reaching there having three of its four plates torn from it and doubled back and the fourth broken half through and twisted completely around. In this neighborhood there are numerous small pieces of plates and angles that can readily be identified as having once belonged to chord A-9-R. Latticing on this chord is completely destroyed.

A-10-R.—The field splice between A-9-R and A-10-R is partly broken. Starting from that point, A-10-R runs north and inclining slightly eastward to a point near the south end of the stub chord. A-11-R, pinned on the 24-in. pin, its field splice with which is entirely broken. The ribs of A-10-R are comparatively straight, but are piled over, one on the other, and the latticing entirely destroyed.

A-11-R and L.—These "V"-shaped stub chords are still in the positions originally placed on the 24-in. pins holding them to the main pier shoes. Their field splices with both the number 10 chords of anchor and cantilever arms have been broken off entirely, but the chords themselves damaged but little. (Signed) Henry Holgate,
Chairman.
J. G. G. Kerry.
J. Galbraith.

APPENDIX 13, REPORT OF QUEBEC BRIDGE COMMISSION.

An Examination of the Various Full-size Column Tests That Have Been Made in America, Accompanied by Diagrams Showing the Results of These Tests.

In view of the circumstances accompanying the accident of Aug. 29, it was necessary for us to investigate the design of the lower chords and the data that were at the disposal of the designer (The Phœnix Bridge Company's engineer) when he began his work. This investigation was commenced by an examination of all obtainable records of column tests.

The column formulas used in practice are, broadly speaking, empirical formulas, framed to suit the results of these tests.

In examining the records, a process of elimination was adopted, the object being to select those tests which most nearly corresponded to the Quebec Bridge conditions. The following are the considerations upon which the selection was made:

(1) No tests on solid sections were used, because the bridge chords were built-up members and apparently failed from weakness of connecting details, the conditions being absolutely different from those existing in a solid section.

(2) No tests on sections that have been proved defective were used, except that certain of the Buchanan tests, which were published in 1907, have been selected on account of the large sections of the test pieces, although these were not of the most approved design.

(3) No tests on members whose failure was caused by defects in the testing apparatus were used. In the earlier tests special ends were fitted to many of the test columns, with unsatisfactory results.

(4) It was intended to exclude all tests on members having less than 10 sq. in. area, but some tests on sections having areas between 7½ and 10 sq. in. have been included.

(5) When the ratio l/r for any column exceeded about 120 the test results were not used.

The records consulted were:

(1) J. M. Moncrieff (Trans. Am. Soc. C. E., Vol. XLV, 1901).

This paper, which was written by an English engineer, contains perhaps the most complete compilation of column test data that has ever been published. It was consulted for reference to original authorities. The records contained in it show that there were practically no English or European tests that would not be excluded by the fourth consideration above mentioned.

(2) "Tests of Metals."

This is the official record of all tests made at the United States Arsenal at Watertown, Mass. The complete file of these volumes, publication of which began about 1881, was examined. No tests of interest were found in any volumes issued after 1884. The results from tests on wrought-iron columns of the Phœnix, box and latticed channel types have been selected. The results of 99 of these tests have been used. The specimens varied in cross-section from 7 to 22 sq. in., there being six with areas between 20 and 22 sq. in. and 14 with areas between 15 and 20 sq. in.

(3) G. Bouscaren (Trans. Am. Soc. C. E., Vol. IX, 1880).

The tests recorded in this paper were made between 1875 and 1879 in connection with the building of the Cincinnati Southern Ry. They included tests on wrought-iron columns of box and latticed channel types. In all nine tests were selected for use. This series of tests has possibly had more influence upon the detail of bridge design than any other series that has been made, as the rejection of various types of columns and the adoption of various modifications in detailing directly resulted from it. The small number of tests that have been selected for this record shows how greatly the tests were needed at the time. The cross-section varied from a minimum of about 11 sq. in. to a maximum of about 14 sq. in., with the exception of one box column which had an area of 26.06 sq. in. The metal used developed an ultimate strength of between 52,000 and 55,000 lb. per square inch, Mr. Bouscaren's specification of 1875 calling for an ultimate strength of 60,000 lb. per square inch in tension.

(4) Clarke, Reeves & Co. (Trans. Am. Soc. C. E., Vol. XI, 1882).

This firm, which was the predecessor of the Phœnix Bridge Co., published in this paper the results of a series of tests on Phœnix columns which were made for them in 1879 and 1880 at the Watertown Arsenal, the material being wrought iron. There were 22 tests in all.

It was found necessary to alter the "breaking load" on some of the shorter columns given in the records, as an examination of the diary of the tests showed that real failure had occurred considerably before the metal managed to escape from the following up of the machine.

Clarke, Reeves & Co.'s specification of 1871 calls for iron of an ultimate strength of from 55,000 to 60,000 lb. per square inch. Twenty of the columns had a sectional area of about 12 sq. in. and two a sectional area of 18.3 sq. in.

(5) C. L. Strobel (Trans. Am. Soc. C. E., Vol. XVIII, 1888).

The tests recorded in this paper were made in 1887 upon columns of H shape built up out of four Z bars with a latticed web. The material was wrought iron and the results of nine tests have been used. The sectional area in each case was between 9 and 10 in.

(6) J. G. Dagron (Trans. Am. Soc. C. E., Vol. XX, 1889).

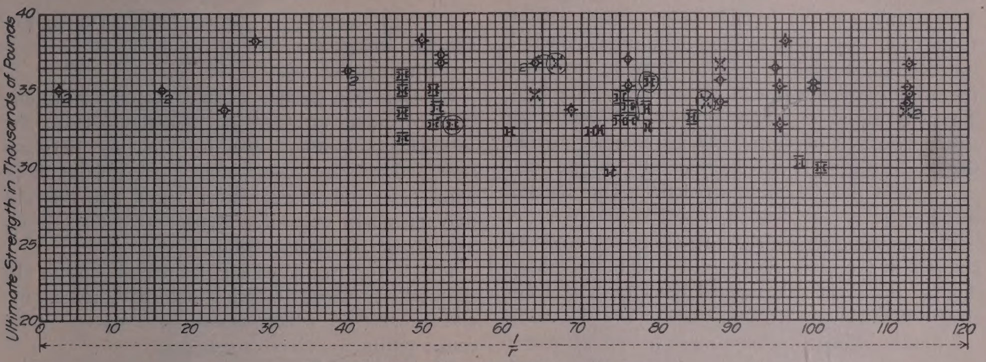
This series of eight tests, all of which have been used, were made 1884-5. The columns were of the latticed two-channel type, the channels being built-up. The material was high steel, the ultimate strength being given at 84,000 lb. per square inch and the elastic limit at 53,000 lb. per square inch. The columns were between 8 and 14 sq. in. cross section.

(7) Prof. W. H. Burr, "The Elasticity and Resistance of the Materials of Engineering."

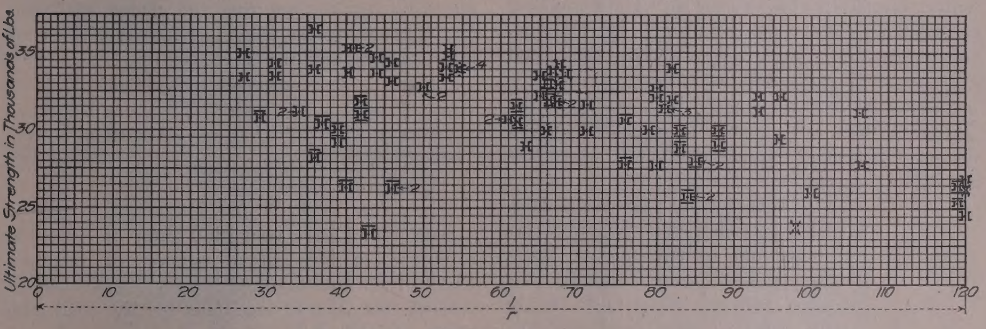
In this book there is given a full resume of column test data, including four tests on Phœnix columns made in 1873, the results of which have been used. The columns were between 8 and 14 sq. in. in cross section.

(8) C. P. Buchanan (Engineering News, Dec. 26, 1907).

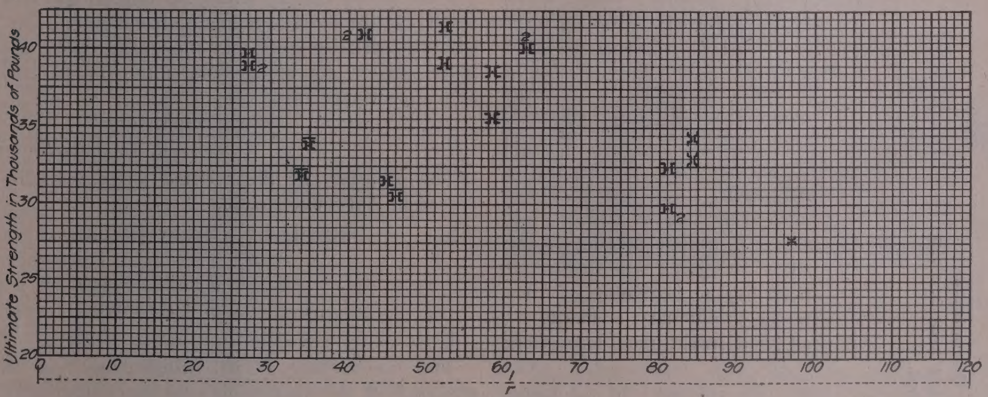
In this paper are given the results of 19 tests made between 1888 and 1900, the sections of the specimens varying from about 14 to 33 sq. in., these being the largest columns that had been tested previous to the investigations made in connection with our inquiry. The results were not made public until the date above mentioned and were not available for use of the Quebec Bridge designers. Twelve of the specimens were of wrought iron, three of Bessemer steel and four of open hearth steel, these last four being of the grade known as "structural steel," which is at present in general use for bridge work. Only six of the specimens were strictly symmetrical. The columns were of the "H," two-channel and upper chord types. All the results have been used, although on account of unsymmetrical sections, and eccentric loading in several cases, high ultimate strength was not to be expected.



FLAT-ENDED WROUGHT-IRON COLUMNS.



PIN-ENDED WROUGHT-IRON COLUMNS.



PIN-ENDED STEEL COLUMNS.

Drawing 20, Report of Royal Commission on Quebec Bridge Failure. Results of Various Full-Size Tests of Columns.

(9) J. A. L. Waddell (Engineering News, Jan. 16, 1908).

This paper gives the results of six tests upon structural steel columns of the two-channel type. The tests were made about 1907. All of the results have been used, the column sections being 17.44 sq. in. in area. The results of the tests on nickel steel columns which were made at the same time have not been included.

The results of 176 tests in all have been plotted, the cross-section of the largest column being less than 33 sq. in. in area, and that of the smallest greater than 7½ sq. in.; three columns had cross-sections greater than 30 sq. in., nine greater than 25 sq. in., sixteen greater than 20 sq. in. and twenty greater than 15 sq. in. The results of the tests are plotted in Drawing 20 and are divided into three groups, viz.: flat-ended wrought iron columns, pin-ended wrought iron columns, and pin-ended steel columns.

The following conclusions may be drawn from this study:

(1) Very few tests have been made on full-size steel columns, and some of those that have been made are upon unusual grades of material.

(2) The experiments upon which modern practice is largely depending were made at least twenty years ago, and upon a grade of material which is not now in use in the construction of bridges.

(3) The decrease of strength with increase of the ratio l/r is, in the case of flat-ended wrought iron columns, not clearly discernable on the diagram in Drawing 20.

(4) This decrease is discernible on the diagram in the case of pin-ended wrought iron columns, but it is not nearly so rapid as the decrease indicated by the column formula adopted in the amended specifications for the Quebec Bridge.

(5) It is evident from the particulars of many tests that the size and strength of the pin used have an appreciable effect on the results obtained, but the amount of this effect has not been determined.

(6) The relation between the strength of a column as determined by test and as calculated by formula varies greatly.

(7) No series of tests have been made to determine the relative stresses in the various parts of a built-up column.

(8) The strength of a column is greatly affected by what have been considered minor features in the end details.

(9) A compression member of usual design and dimensions cannot be expected to develop an ultimate strength much greater than about one-half of the ultimate strength of a tension member made from the same material.

(10) No tests have been made on columns of the form of the Quebec lower chords nor on any having more than about 1/25th of the cross section of these chords.

That the results of laboratory tests should not be rigidly followed in field practice is axiomatic, but the extent to which they can be safely accepted is a matter of judgment. During the last 25 years, a failure similar to that of the Quebec Bridge has been, we believe, unknown, and as compression members designed in accordance with the results of the Bouscaren tests have been uniformly successful. little doubt existed in the minds of practicing bridge engineers concerning them.

There is no definite evidence to show that either Mr. Cooper or Mr. Szlapka ordered any investigation to be made of the test data that were available, and when the comparative magnitude of the undertaking is remembered, it is difficult to explain their failure to check their conclusions on the Phœnix testing machine, which was at their disposal.

On the drawing the results of the tests are shown, arranged according to the ratio l/r for each column. The form of the section upon which each test was made—double channel, H, box, Phœnix, or upper chord—is indicated by miniature sections.

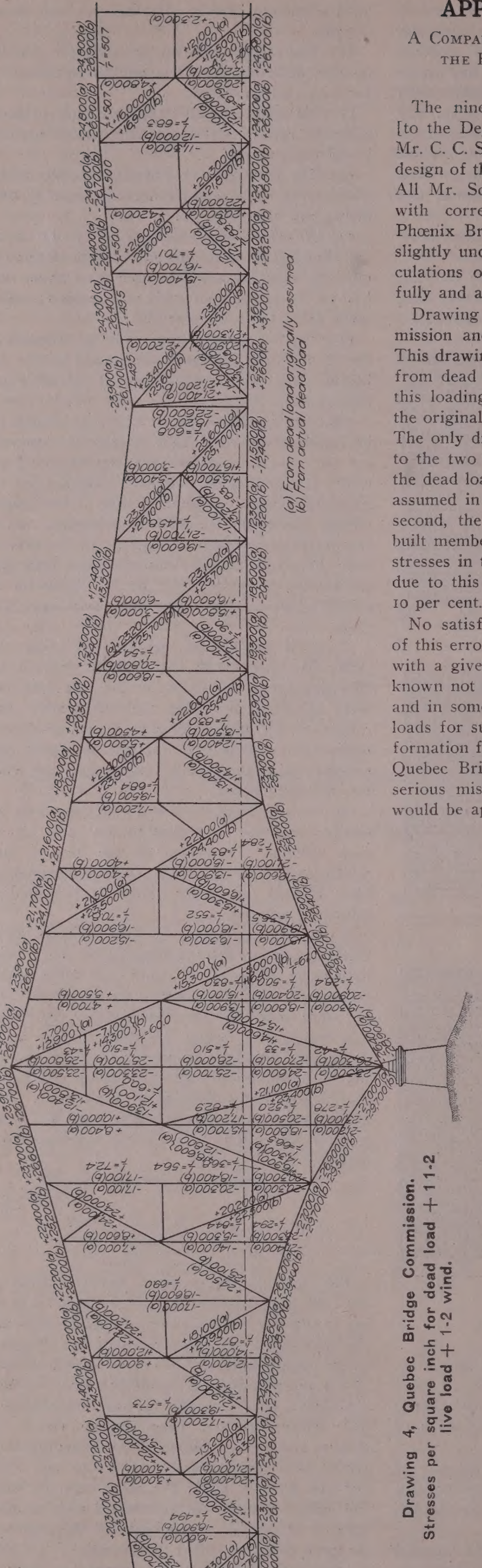
It should be remembered that, previous to the Quebec disaster, the insufficiency of the existing knowledge of column action had been widely recognized, and programmes for additional testing were under consideration both by the American Society for Testing Materials and by an independent committee of prominent engineers, acting in co-operation with the officers attached to the United States Arsenal at Watertown. It is generally felt that modern bridge work has grown to such dimensions that further investigation is desirable.

(Signed) HENRY HOLGATE,
Chairman.
J. G. G. KERRY.
J. GALBRAITH.

THE USE OF MECHANICAL REFRIGERATION for the cold storage of cut flowers and bulbs is growing in practice in horticultural establishments near the large cities. A 20-ton refrigerating equipment of the compression type has recently been installed at the green-houses of Poehlmann Bros., at Morton Grove, near Chicago, for the maintenance at low temperature of four storage rooms for flowers and bulbs. Two of these rooms are maintained at a temperature of 38 to 40 deg. Fahr., for cut flowers, while the other two, in which lily bulbs are kept, are maintained at a temperature of 24 deg. F., the purpose of this low temperature being to retard the growth of the bulbs so that their planting may be timed for blooming at the exact period when the market demand occurs. The refrigerating equipment is a Linde system, with direct ammonia expansion coils in the cold storage rooms, local brine circulation being used for maintaining the temperature in the cut flower store rooms only.

APPENDIX 14, REPORT OF QUEBEC BRIDGE COMMISSION.

A Comparison of the Stresses in the Several Members of the Main Trusses, Computed From the Bridge as Finally Designed, With the Stresses Authorized by the Specifications.



(a) From dead load originally assumed
(b) From actual dead load

Drawing 4, Quebec Bridge Commission.
Stresses per square inch for dead load + 1 1-2 live load + 1-2 wind.

The nineteen tables accompanying the report [to the Department of Railways and Canals] of Mr. C. C. Schneider, consulting engineer, upon the design of the Quebec Bridge, are self-explanatory. All Mr. Schneider's results have been compared with corresponding figures furnished by the Phœnix Bridge Co. and in general are found to slightly underrun them. They show that the calculations of the Phœnix Bridge Co. were carefully and accurately made.

Drawing No. 4 has been prepared for the Commission and revised by the Phœnix Bridge Co. This drawing shows the maximum stresses arising from dead load, plus 1½ live load, plus ½ wind, this loading having been used to some extent in the original calculations at Mr. Cooper's direction. The only difference in the calculations leading up to the two sets of figures on the drawing lies in the dead load used; for the first set the dead load assumed in the designing was taken, and for the second, the actual dead load obtained from the built members. It will be noted that the error of stresses in the main chords near the center posts, due to this error of assumed dead load, is fully 10 per cent.

No satisfactory explanation of the occurrence of this error has been offered. On minor bridges, with a given live loading, the weight of metal is known not to vary greatly with details of design, and in some offices revision of the assumed dead loads for such bridges is not the rule; but no information from which to predict the weight of the Quebec Bridge existed and the probability of a serious mistake in the first estimate for weight would be apparent to a cautious designer.

The fact is that Messrs. Deans, Szlapka and Cooper permitted the shops and rolling mills to commence work without taking any steps to test the correctness of the assumed dead load, and the probable dead load does not appear to have been estimated from the plans until at least eighteen months after the work of fabrication was commenced. (See Appendix No. 8, Eng. Record, March 14.)

A list showing the dates on which each shop drawing was computed is filed as Exhibit No. 125 and it will be noted that the work of designing was so far advanced by the beginning of 1905 that the preliminary estimates of dead load might then have been revised with considerable accuracy. By reference to Appendix No. 8, it will be seen that the percentage of error in the original estimates for all parts of the spans was roughly the same.

We are of opinion that no manufacturing should have been done until the designers had so far advanced with their work as to be able to make a proper estimate of the weight of the bridge (see clause 3 of 1898 specification, Exhibit No. 21). Before completing the drawings for use in the shop the weight of the various parts should have been computed as a check on the estimated weight of the bridge. As a matter of fact, this procedure was not adopted and manufacturing was commenced in July, 1904, without any such checking, although the specifications called for it, and the contract practically demanded it. (See Appendix No. 8.)

The designing office had accumulated sufficient information to enable it to make a close estimate of the weight of the bridge but did not do so. On the contrary, work continued as if their assumptions had been correct.

That Mr. Cooper fully intended to permit stresses in excess of 24,000 lb. per square inch under the conditions used for drawing No. 4 is shown by the following letters:

"August 6, 1904.

Phœnix Bridge Co.,
Phœnixville, Pa.

My Dear Mr. Szlapka: I have tested the proportions of the members of the anchor arm under the following maximum loading for my personal satisfaction—viz: Dead plus 1.5, live plus 25 lb. of wind (½ of your wind strain) and find that the only members exceeding 24,000 in tension or 24,000-100 l/r for compression are—

The lower chord which has 26,500 and is all right and Towers L, which should have 108 sq. in., and Towers B, which should have 99 sq. in. to come within the above conditions.

This is such a slight matter I request for the sentiment of the thing that you change those last two members to the above sections if it does not inconvenience anything.

Yours very truly,
(sgd.) Theodore Cooper.

August 9, 1904.

Theo. Cooper,
Consulting Engineer,
New York, N. Y.

Dear Sir: I have your kind letter of Aug. 6 in reference to increase of section of members TLOOOOO and TBOOOOO for combination of stresses due to dead load plus 1½ live load, plus wind.

I will gladly comply with your request and will also apply the same combination to all other members to satisfy myself that the unit stresses are in proportion not higher than those on the two above mentioned members.

Yours respectfully,
(sgd.) P. L. Szlapka.

The propriety of the selected stresses is discussed in Appendix No. 18.

(Signed) Henry Holgate,
Chairman.
J. G. G. Kerry,
J. Galbraith.

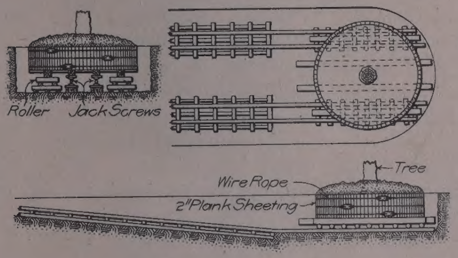
The Gas-Engine Pumps which have been in operation at the water-works of Brookville, Ohio, a village of 1,200 inhabitants, for the past three years, are reported to have given very satisfactory results. The equipment consists of two 25-h.-p. New Era single-cylinder gasoline engines, with 11½ x 18 in. cylinders, operating four cycle, which are each belt-connected to an 8 x 10-in. triplex single-acting Smith-Vaile pump having a capacity of 300 gal. per minute at 50 r.p.m. The water is distributed through approximately three miles of pipe, having at present 111 service connections. The distribution is by pneumatic pressure, maintained at 50 to 80 lb. on the mains, when the pumps are not in operation, by compressed air in two storage tanks 8 ft. in diameter and 36 ft. long. Both engines have always, it is said, been readily started, the two having been started at one time in 4 min. when cold, and with one exception, they have never stopped of their own accord. For the year ending July 1, 1907, the gasoline bill was $125.26.

A Method of Moving Large Trees.

Within a few years a number of large trees have been transplanted in the vicinity of Pittsburg and have been successfully raised, traversed and lowered to position at the new site by the use of ordinary house mover's apparatus. The method used is quite simple, as will be seen from the following description.

A circle from 10 to 30 ft. in diameter, according to the size and variety of the tree, is described about its trunk and a concentric annular trench from 3 to 6 ft. deep and about 3 ft. wide is excavated and a full width slope from the bottom of it to the surface of the ground is excavated on one side. The inner side of the trench is sheeted with 2 x 10-in. vertical planks set close together and securely tied in position by two or three horizontal lines of wire rope with sleeve nut adjustments. A diametrical tunnel is then drifted under the sheeting and in it are set two 12 x 12-in. needle beams a few feet longer than the diameter of the trench. The ends of the beams are raised slightly by jackscrews to take the weight of the tree and of the earth enclosed by the circular sheeting.

The tunnel is widened out to the trench on both sides of the needle beam and two short 12 x 12-in. beams are inserted parallel to the needles, the spaces between them are sheeted with horizontal boards to support the earth, rollers are inserted under the outer timbers, and the jackscrews are slacked off until they carry the weight of the tree and the enclosed earth and release the screws which are then removed, and all of the roots having been cut off, the tree is easily pulled up the gentle slope out of the pit and transferred to its new locality where it descends another inclined plane to the bottom of the pit provided for its reception. Needle beams are placed under the center and jacked up to release the rollers and outside track beams and the place of the latter is back-filled with earth well-rammed in position which serves as a support for the trees. The jackscrews are slacked off and removed, the needle beams above them withdrawn and the center space finally filled with earth, completing the work. In this manner trees as much as 50 ft. high, which with their roots and earth were estimated to weight about 70 tons, have been successfully removed 500 ft. by a force of about eight men in one to two weeks by the John Eichleay, Jr. Company, Pittsburg, Pa.

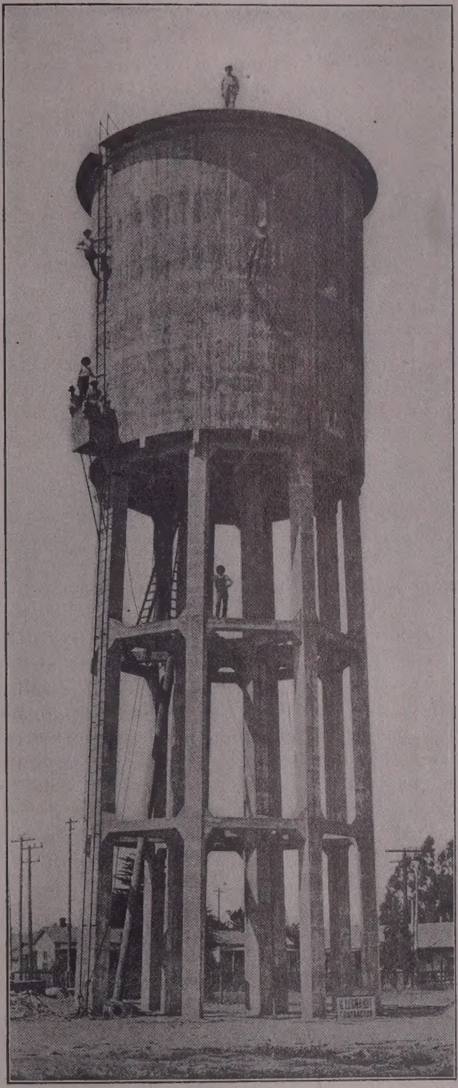


Trench and Needles for Moving Trees.

A Steam-Turbine Pump recently installed in a scout cruiser for the U. S. Navy for hot well-pumping, is so compact that the type may be useful in the crowded basement engine-rooms of many large buildings. It consists of a 4-in. Worthington two-stage volute pump mounted on a heavy baseplate with its shaft vertical, and above, mounted on a light steel framework, a two-stage Curtis steam turbine direct-connected to the pump shaft, and operating at 1,200 r.p.m. The entire outfit, which has a capacity for delivery of 300 gal. of water per minute from a 29-in. vacuum, occupies a floor space only 3 ft. square, and is 9½ ft. high.

The Reinforced-Concrete Water Tower at Anaheim.

A reinforced-concrete water-tower, with a tank having a capacity of 200,000 gal., has recently been completed and placed in service in connection with the reconstructed water-works system at Anaheim, Cal. The reasons for selecting this type of structure, the conditions governing the design and the general features of the latter were fully discussed in The Engineering Record of Aug. 24, 1907. The construction, which was in progress at that time, has since been finished with entirely satisfactory results, and its appearance is shown in the accompanying illustration. At the time the contract for the construction of the tower was awarded proposals had been received for a steel tank on a steel tower, and for a tank and tower of reinforced concrete. The prices submitted for the steel structure ranged from $9,200 to $12,500, while two bids for concrete towers were received, one for $10,400 and the other much higher. The lower bid for the concrete structure was accepted, and the tower was built for this sum.



Anaheim Water Tower.

The tower has a total height of 102 ft., the bottom of the tank being 60 ft. above the ground. The tank is 30 ft. in diameter and 32 ft. high. The walls of the tank vary uniformly from 4 in. in thickness at the top to 6 in. at the bottom. They are made of concrete in the proportions of 1 part Portland cement, 2 parts river sand and 2 parts broken stone, crusher run of stone with ½-in. pieces as the maximun used. The forms for the walls were continuous from the bottom to the top and were built thoroughly tight. The lagging of the forms consisted of 1 x 3-in. tongue and grooved pine flooring in 30-ft. lengths which were placed vertically and well braced in position. The concrete was made quite wet and was poured into the forms as nearly continuously as possible to overcome any tendency toward lines of cleavage in it.

The forms were allowed to remain on the walls of the tank until the last concrete in them had been placed for about two weeks. After they were removed a 1 to 1 sand mortar coat, ½ in. thick, was applied to the interior surface and then this coat was painted with a neat cement wash. As the walls thus waterproofed were not entirely tight, and the contractor particularly desired to produce a perfectly tight tank, the mortar coat was removed and a plaster coat of neat cement, ¼ in. thick, was painted over the interior surface of the wall.

The walls were rendered practically impervious in this manner, as the tank showed no leaks when it was filled after the coat of neat cement had been applied directly to the concrete. In several spots, however, moisture penetrated through the concrete at first sufficiently to produce dampness on the outside. Since then these spots have gradually been reduced in area until they have almost entirely disappeared. The water stored in the tank also carries considerable alkali salts which are expected to fill the pores of the concrete enough to cause this slight appearance of dampness on the outside of the walls to be completely overcome.

The standpipe was designed by Mr. F. R. Schanck of Messrs. Clem A. Copeland and F. R. Schanck, consulting engineers, of Los Angeles, who were in charge of the reconstruction of the municipal electric lighting and water-works systems of Anaheim. Mr. A. L. Lewis is superintendent of these systems. The water tower was built by Mr. Carl Leonardt, general contractor, of Los Angeles, for whom the late Mr. T. F. Osborn was engineer in charge of design and construction.

Letters to the Editor.

Flattening Rolled Drawings.

Sir: In The Engineering Record of March 21, Mr. Jas. F. Storz describes a method he used to flatten rolled maps, while installing a flat map-filing system in a railroad office, which consisted in immersing prints in water and then hanging them up to dry again while tracings were held over an oil heater. While in charge of the drafting room of the Department of Water Supply, Brooklyn, I had to flatten several hundred rolled maps. All of them were unrolled and placed on a table, face down, and kept in that position by weights. Then a hot flatiron was applied to and over the whole surface of each map until the whole stack of maps was gone over, removing each map as soon as the whole surface is gone over with the flatiron. The irons were heated on a small gas stove connected with a jet.

Yours truly,

New York, March 21. J. Peterson.

Regulators for House Heaters.

Sir: I read with interest the articles by Mr. P. W. Kafer and Mr. C. C. Witt, in the numbers of Feb. 29 and March 21, respectively, describing two methods of automatically opening the dampers of a house furnace in the morning. I made an apparatus of this nature for my own house, which, I think, is a little simpler than either of those previously described.

I used an ordinary alarm clock, and converted the stem which winds the alarm spring into a small pulley. String was wound around this pulley and carried by means of overhead pulleys to the furnace. The damper in the main flue and the swinging ash-pit door are held closed during the night by this string. Then, when the alarm goes off, the alarm stem unwinds slowly and the damper and ash-pit door are opened by means of suspended weights. The clock is firmly anchored and carries the strain of the above mentioned weights all night.

The advantages of this system are that it does away with all electrical apparatus, and, by performing its operations slowly, avoids any possible damage due to quickly falling weights. The alarm was set for 6 a. m. and by 7 a. m. there was a good pressure of steam in the boiler, and the house was comfortably warm. Yours very truly,

New York, April 4. Glegge Thomas.

Formulas for Concrete Beams.

Sir: In your issue of March 21 Mr. Lechler, in discussing the writer's new formulas for reinforced concrete beams (Eng. Record, March 7) makes some comparisons that are inaccurate. When, for instance, he states that the commonly accepted formula, $d = 0.26\sqrt[3]{M}$, gives practically the same gross dimensions for the beam as does the new formula, he goes wide of the mark unless he considers one girder practically the same as another having 20 per cent. more area. Again, when he compares the new formula for area of steel required with the commonly accepted one ($d^2/160$ he changes the writer's formula ($d^2/144$) to $d^2/72$ and then makes the erroneous statement that the new formula calls for two and one-fourth times more steel than the old one. It is easy to see that no direct comparison of the old and new formulas is possible for the value of d is different in each case. I would suggest that Mr. Lechler apply the formula to a practical example, say, a beam 30 ft. span to carry a uniform load of 150,000 lb. For this particular case the new formula gives $d = \sqrt[3]{(0.0135M)} = 45$ in. and an area of steel required equal to $d^2/144 = 14.17$ sq. in. The commonly accepted formulas give $d = 0.26\sqrt[3]{M} = 49.14$ sq. in. and an area of steel required of $d^2/160 = 15$ sq. in. In other words, his girder will be over 20 per cent. more sectional area and 7 per cent. more steel when figured according to the old formulas. Besides economy the great advantage of compactness derived from the new formulas will be appreciated when it is remembered that for heavy loads and long spans the enormous dimensions of these girders often renders their use prohibitive. Regarding the contention that the arrangement of bars in Fig. 2 of my letter in your issue of March 7 would give a curved neutral surface, perhaps Mr. Lechler means that the bar just below the apex of the lower triangle should be triangular in shape, forming a knife-edge along the neutral line. This is quite correct, as we would then have ideal conditions; in fact, this is assumed to be the case in the derivation of the formulas. But Fig. 2 shows how ordinary bars may be arranged in practice so as to form as perfect a triangle as possible without using special shapes.

Yours very truly,

New York, March 26. A. P. Jacobs.

Artistic Treatment of Concrete Surfaces.

Sir: The proper treatment to give a pleasing appearance to exposed concrete surfaces has been one of the most difficult problems before the concrete engineer. Many engineers experienced in good concrete work prefer not to attempt to secure perfect finish in the forms, but to dress the entire concrete surfaces by some style of tooling, rubbing or washing process, after the removal of the forms. The effort of some architects and builders to overcome the defects of the material by making the surface assume the appearance of stone has caused the public to associate with concrete the idea of deception and cheap imitation.

Reinforced concrete structures decorated with exterior ceramic mosaic or enameled tile will be the future method of constructing our important buildings, as well as the mechanics' dwelling houses. The time is not far distant when architects will agree that concrete with ceramic embellishments is equally as valuable a medium of artistic architectural expression as any of the older building materials. French architects have already declared that because they are nonporous to moisture, gases or dirt, the use of enameled tile in exterior work will prove the eventual solution of the problem of deterioration and discoloration of most of our present building materials when exposed to the atmosphere of large cities. The tiles form an artistic and lively treatment, the effect of which is only accentuated by the increasing surface dulness of the concrete background.

The use of decorations has been limited principally to a facing put on the wall after the completion of the structural work, but by the employment of a patented invention, which bids fair to prove one of the greatest building improvements of the age, the ornamentation is now placed in position while the concrete is being poured, thus forming a part of the wall. The tiles are taken as they come from the factory on paper sheets and pasted face down to a perforated steel plate with "Holdum" solution, which after drying is set in position in the wall ready for the concrete backing, thus becoming a part of the wall instead of a covering. After the concrete has set the proper length of time, the paste is readily dissolved by water forced through the holes in the plate. The plate and paper are easily removed after a few minutes' application of water, leaving an artistic finished surface at a fraction of the cost when tile is placed with mortar and trowel.

Pebblecrete or Marblecrete wall surfaces can also be effected by embedding pebbles, marble chips or colored stones in "Holdum" solution spread upon steel plates about ⅛ in. in depth, and after this jelly preparation has hardened on the plates they are set in position in the forms the same as for tile walls above, and the concrete composed of only cement, sand and gravel or crushed stone is worked in around the pebble facing. After a reasonable time, water is forced through holes in the plate, causing the paste to dissolve, allowing the plate to be removed, and leaving the pebbles or chips to stand out in bold relief, giving an artistic, inexpensive and high-class modern finished surface. The above methods have been patented by Mr. William Deane Ham and are now being successfully exploited by a corporation known as Monolithic Hollow Wall Co., with home offices in the Monolith Building, New York City.

Yours truly,

Philadelphia, March 26. Frank B. Test.

Septic Tank Patents.

Sir: Enclosed please find a copy of a letter sent March 13, to the American Society of Civil Engineers, which explains itself. It refers to a question which merits serious attention at the present time from all sources. Yours very truly,

New York, March 21. Alexander Potter.

[The enclosure referred to by Mr. Potter reads as follows:

"Last week the writer had forwarded to him a circular letter from a municipality in which he had constructed a septic tank, which circular letter, written by a member of this Society, requested the municipality referred to to contribute $100 now, with a prospect of contributing an additional $200 at a later time, to carry the fight against the patentees of the septic tank to the Supreme Court of the United States. This municipality requested an opinion from me as to their course in the matter, which I was not able to give.

"Another town receiving a somewhat similar letter, asked the writer why he had constructed their system without having the royalty claims arranged. This question also I was not able to answer in a satisfactory manner, any more than most of the engineers throughout the country could answer it.

"In still another city, on the eve of an election, an engineer addressed a letter to the public advising the people to defeat the sewer proposition. One of his chief grounds for such advice was, that the municipality would be in no very good situation to make favorable terms with the patentee if the plans had been previously adopted by the people at the polls.

"The writer holds no brief for the Cameron Septic Tank Company, but he desires to make a plea to the municipal engineers of the country that they put forth the same energy in trying to come to a reasonable agreement with the patentees of the septic tank, as some are putting forth in resisting the payment of a debt that we undoubtedly owe to Mr. Donald Cameron, the patentee of this septic tank. It seems to the writer that an agreement could be reached by the engineers that would be fair both to their clients and to the patentee. That they owe something to Mr. Cameron is clearly evidenced by the widespread and general adoption of the septic tank as an integral part of sewage disposal throughout the United States and Canada. As to the cash value of this debt, the writer frankly admits he has not given the matter sufficient attention to reach a conclusion, but does not consider that engineers are warranted in ignoring the obligation.

"There is no well established law, written or unwritten, that makes it a misdemeanor or even unprofessional to patent engineering inventions of general utility. The law of the land recognizes the right of an inventor to a reward for his invention. In most all other lines of work patents are considered proper, but when an engineer essays to patent anything useful, he frequently becomes the storm-center of an attack from all his fellows. This attitude does not make for advancement along either scientific or practical lines. If an inventor is allowed to enjoy the fruits of his invention it will act as an incentive to others to develop still other improvements, and the whole community is thus benefited; the public have more systems to choose from and monopoly is prevented. In the case of the septic tank, however, most of us will admit that while it is almost an essential part of sewage purification as we now know the art, we have, perhaps, unwittingly aided in depriving the man who first brought it to our attention of the fruits of his labors. It seems to the writer that a city should not be deprived of the use of methods of such universal application as the septic tank, but that an effort should be made to secure from the Cameron Septic Tank Company some agreement that would not only be just and equitable to the company, but that would give all engineers the right to use the septic tank as a part of their design, without feeling that they may be involving their clients in some unknown and exorbitant fees for royalty.

"The writer would therefore suggest that this Society take some initiative in this matter and endeavor to reach a conclusion which could be accepted as fair, alike to the Cameron Company, to engineers who make such use of this patent, and also to the cities for whom such designs are made. The present attempt to carry this case to the Supreme Court will unquestionably tend to delay public improvements, and, in the writer's opinion, it is the proper function of this Society to effect remedial conditions in such an instance."]

A Spandrel Wall on a reinforced-concrete bridge over Tucker Run on the Ohio Electric Ry. failed recently, due it is said to placing the fill before the concrete had thoroughly set.